ENGINEERING ECONOMIC ANALYSIS

OF A RAIL EXTENSION FROM DUNBAR SIDING TO LIVENGOOD, ALASKA

By

Charles W. Bohart

RECOMMENDED:

Dr. Scott L. Huang

Dr. Debasmita Misra

Dr. Paul A. Metz, Advisory Committee Chair

Dr. Rajive Ganguli, Department of Mining and Geological Engineering Chair

APPROVED:

Dr. Doug Goering, Dean, College of Engineering and Mines

Dr. Lawrence Duffy, Dean of the Graduate School

Dec 6, 2011

Date

ENGINEERING ECONOMIC ANALYSIS

OF A RAIL EXTENSION FROM DUNBAR SIDING TO LIVENGOOD, ALASKA

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

By

Charles W. Bohart, B.S., EIT

Fairbanks, Alaska

December 2011

Abstract

The Dunbar Siding to Livengood rail extension study is an economic prefeasibility investigation, and is conducted from two perspectives as a cost benefit analysis. The first perspective is, that of the Alaska Railroad Corporation (ARRC) in which the capital and operating costs of the proposed extension are recovered through the revenue stream resulting from the out-bound mineral freight loads, the in-bound re-supply freight loads, and the potential commuter passenger service to mining projects and communities in the Livengood area. The second perspective is that of the private sector in which a shipping sensitivity and employee transport analysis with respect to mining project developments. The large mineral resource base within the Dunbar-Livengood Corridor indicates an excellent freight potential with generous benefits for Alaska's economy of greater than $2 billion annually in gross revenues; whereas, resource and rail development are synergistic.

Preface

This thesis is written with an aim toward an American Engineering and Investing audience. Imperial units are used within the discussion and SI units are noted for reference for other readers, historical accuracy, and consistency. In this document, the terms metric ton or tonne represent the SI unit for a metric ton or 1000 kilograms. The unit ton is a reference to short ton or US ton or 2000 pounds. In reference to mineral grade ounces per ton refers to troy ounces per US short tons and parts per million (ppm) refers to grams per metric ton. The conversion for ppm to troy ounces per ton is 34.2857 grams per tonne to 1 troy ounce per ton (Columbia, 2010). The conversion for short ton to metric tons is 1.102311 short tons per metric ton (Columbia, 2010).

Acknowledgements

Funding for this research is provided through the Alaska Canada Rail Link Project under a Reimbursable Service Agreement between the University of Alaska Fairbanks and the Alaska Department of Transportation/Public Facilities. The Principal Investigator is Dr. P. A. Metz. Thank you, Dr. Metz for the opportunity to work under you. Thank you, Dr. Huang and Dr. Misra for serving as my committee members and offering your editing comments. Special thanks to each of the fellow project researchers: Elliot Thorum, Peppi Bolz, Matt Billings, and Kyle Obermiller. Thank you, Dr. Walsh and Eric Hill for your input and comments on the mine model. Thank you, Paul Taylor, Benjamin Bohart, Rui Zhenhua, and many others for your comments and support. I must also thank my family for the many hours of patience and support during this course of study.

Table of Contents

List of Figures

List of Tables

Abbreviations and Acronyms

ARDF	- Alaska Resource Data Files
ARRC	- Alaska Railroad Corporation
bcy/d	- bulk cubic yards per day
CIP	- carbon in pulp
DMU	- Diesel Motive Units
DNR	- Department of Natural Resources
g	- gram
GMV	- gross metal value
ITH	- International Tower Hill Mines
IRR	- internal rate of return
kg	- kilogram
km	- kilometer
kW	- kilo-Watt
kWh	- kilo Watt hour
lb	- pound
mcf	- thousand cubic feet
mbf	- thousand board feet
NHTSA	- National Highway Transportation Safety Association
NPV	- net present value
OMB	- Office of Management and Budget
PEA	- Preliminary Economic Analysis
ppm	- parts per million
ROM	- run of mine
TVSF	- Tanana Valley State Forest

1.0 Introduction

1.1 Opening

The Dunbar siding-Livengood rail extension is a two part prefeasibility study conducted as a cost benefit analysis of the rail extension and the economic impact that extension has on the adjacent mineral resources. The economic analysis is conducted from two perspectives. The first perspective is from that of the Alaska Railroad Corporation (ARRC) in which the capital and operating costs of the proposed extension are recovered through the revenue stream resulting from the out-bound mineral freight loads, the in-bound re-supply freight loads and the potential commuter passenger service to mining projects and the communities in the Livengood area. The second perspective is from that of the developer of a major gold occurrence near Livengood in the form of a shipping sensitivity and employee transport analysis. International Tower Hill Mines' (ITH), Livengood Project, known as Money Knob Project, will benefit from the decreased transportation costs of rail versus truck, and increase the net revenue and the rate of return on investment capital. Both entities are directly dependent upon tonnage transported and the profit margins increase with tonnage. The mine model is pertinent to the rail model because the mine model is the initial freight generator.

Thirty percent of Alaska's communities are not connected by the road or ferry systems (Hughes and others, 2002). Extending the rail system to Livengood is the first step in expanding the rail to the Yukon River. Then eventually from the Yukon River north to the Brooks Range, then west to Ambler Mining District and Nome, and north to the North Slope Oil Fields. Most of the transportation routes and roads in Alaska were developed by, and in support of, mineral resource discovery and mining. This research shows the economic benefits to ARRC, where the capital investment and operating costs are recovered through the freight and passenger revenue streams. The primary benefits to the Alaskan residents and businesses are the revenue streams added to Alaska's economy. The secondary benefits are two jobs in direct support for each mining job (Rogers and Calvin, 1999). The secondary jobs are fuel truck drivers, equipment sales personal, subcontracted construction workers (roads, buildings), etc.

Freight is generally, transported to Fairbanks by rail, and then trucked farther north. With the

Dunbar–Livengood Rail extension, north bound freight could be railed directly to Livengood, reducing both the shipping distance by 100 miles and highway maintenance expenditures by several hundred thousand US dollars per year along the Elliott Highway from Fairbanks to Livengood. Approximately one month each year, the State of Alaska Department of Transportation Public Facilities imposes weight restrictions, limiting the axle load for commercial vehicles, which further reduces trucking efficiency to protect the road structure (Young, 2010).

The purpose of this investigation is to show justification for the Dunbar – Livengood Rail Extension based on the potential freight volume. Rail infrastructures are typically large, permanent, long life projects which transport large tonnages of bulk commodities and heavy equipment. It is essential to forecast the freight volume for thirty to fifty years to establish the need for large infrastructures such as a rail road (Christensen, 2009). The freight volume is used to determine the freight rate necessary to recover the capital cost and operating cost of the rail extension.

1.2 Foreground

Extensive work has transpired studying railroad expansion by and with: the Rails to Resources, the Alaska Canadian Rail Link (ALCAN), the Yukon Short Track Report, the Northern Rail Extension: North Pole to Delta Junction, among others(Boland and others, 2007a, b; Boland and others, 2008; Christensen, 2009; Rutson, 2009). This is a two-part prefeasibility study of the rail extension from the Dunbar siding, near Nenana, to Livengood. The economic analysis is conducted from two perspectives forming a social cost benefit analysis. The first perspective is from that of the ARRC in which the capital and operating costs of the proposed extension are recovered through the revenue stream resulting from the out-bound mineral freight loads, the in-bound re-supply freight loads and the potential commuter passenger service to both mining projects and communities in the Livengood area. The second perspective is from that of the 'public private' sector in the form of a shipping sensitivity analysis and employee passenger transport analysis where the major benefits are the savings from the lower rates. The 'public private' sector or the term 'public' is defined here to represent the private corporations which benefit from the ARRC services. For example, International Tower Hills Mines' (ITH) Livengood Project, known as Money Knob Project, will benefit from the decreased transportation costs of rail versus highway; thereby, increasing the net revenue and the rate of return on investment capital.

The Alaska and Yukon Governments have investigated the development of an Alaska Canadian Rail link under ALCAN Railink Inc., the project manager Kells Boland (Boland and others, 2007a, b, c, d). Several reports have been written assessing the need, costs, and benefits associated with the Alaskan Canadian rail link. The large freight tonnage resources are identified as the coal and iron ore reserves in interior Yukon and other base metal reserves. The higher cost of trucking the freight could lead to a boom and bust cycle in developing these resources. However, the low cost rail freight transport will smooth out and extend the life of the natural resource projects. The ALCAN research indicates the revenues from the rail freight would not recover the capital and operating costs for the Alaska Canada Rail Link. The research also assesses the social benefits in excess of the costs which justify government funding for the rail link through grants and bonds. These reports provided the initial operating cost estimates of two cents per ton-mile and a method of approach as inputs for the cost benefit analysis. The initial operating cost estimate of two cents per ton-mile was contested as too low, upon review.

The Yukon Department of Economic Development commissioned the Yukon Short Track Report to look specifically at using rail infrastructure between mineral resources and access ports as an alternative to heavy haul trucking of mine goods in Yukon (Boland and others, 2008). This report identifies the current mineral industry is growing, the operation costs of the current highway system are rising, and the social costs are increasing as well. Transferring the heavy haul highway traffic to railways would increase safety by decreasing accidents and also lowering the highway maintenance costs. This report was found after using the ARRC financial statements to estimate the operating costs for the Dunbar to Livengood rail extension and it confirms the operating cost estimate of six cents per ton-mile.

The Dunbar-Livengood Rail extension commuter rail service is a significant component of the rail extension for mine employees and surrounding Minto Flats community members related to the vehicle and land use externality costs. Similar commuter transport research conducted by Raju (2008) for the Kansas City Light Rail Project determined the NPV analysis shows a loss; whereas, the Social Cost Benefit Analysis shows a profit because the externalities are accounted for in the social cost benefit analysis. Raju's (2008) work reviewed other studies (Delucchi, 1996, 1998; Levinson and Gillen, 1998) and found estimated external costs for vehicle traffic and land use impacts range from 14 to 59 cents per vehicle mile. Raju's (2008) conclusion finds a simple revenue analysis misses the benefits large projects generate as positive externalities which need to be counted, assessed, or summed into the analysis. In a similar fashion the research for the Dunbar to Livengood extension is complex requiring a macro perspective to include the many diverse resources, costs, benefits, and politics which affect the individual entities collectively and autonomously; paralleling previous work (Hartwick, 1977, 1978; Abacus, 1991; Hanson, 1992; Toman, 1994; Battelle, 1995; Davis, 1998; Ashcroft and others, 1999; Ybarra, 2001; Wright and Czelusta, 2002, 2003; Boadway, 2006; Litman, 2006; FRA, 2008; ICF, 2009; Gordon and Kolesar, 2010).

The benefit analysis for the ARRC uses the net present value for the positive freight revenues above the operating costs. The hurdle rate or minimum return on investment is argued to reflect the similar rates of return in large capital investments such as the Alaska Permanent Fund, ~15 percent, or the OMB rate, 7 percent. The Office of Management and Budget (OMB) rate is based on recent pretax private invest rates of return. It is noted that large public projects may use a lower hurdle rate, 5 percent or less, approaching the 2011 thirty year U.S. Treasury Bond rate, 4.64 percent (Bloomberg, 2011). The ARRC is able to sell bonds at the US Treasury rate to finance project capital costs. The costs are brought to net present value for an equivalent comparison with the benefits to the ARRC. The operating costs are excluded from both the benefit and the cost analysis as they are canceling.

The analysis of the public benefits is vast and broad, covering the private entities of mining, forestry, freight transport, tourism, road maintenance, reduced road traffic, public safety, and economic growth. The public benefit analysis begins with the revenue savings from the reduced freight rate, and then expands into the savings generated from the commuter transport: reduced personal vehicle operation and maintenance, avoidance of permanent on-site housing requirements, more employee time at home, and higher productivity from employees rested during travel. This study is not able to define and discuss all the individual benefits and will focus on the major benefits: reduced shipping costs, mine employee transportation, and mine employee housing costs. The benefits will be brought to present value for comparison with the cost.

The data for the ARRC operating costs is derived from their financial reports. The capital costs are estimated from the "Rails to Resources to Ports" , the "Yukon Short Track Report" , and the "Northern Rail Extension EIS" (Boland and others, 2007a; Boland and others, 2008). The benefits are estimated at several freight rates. For each freight rate, the natural resource tonnages will be added sequentially to analyze the benefit cost ratio. The potential freight sources within the rail corridor are: Money Knob gold Project, Shorty Creek copper Project, Globe Creek limestone Project, 417 other Alaska Resource Data File recorded prospects, Tanana Valley State Forest timber resources, Tourism and truck on rail. The result is a benefit cost analysis with sensitivity to tonnage.

The second perspective, from the public, will individually look at the summed net present benefits for each of the natural resources, based on the cost savings of a lower shipping rate. The same shipping rates used in the first perspective will be used in the second perspective. This analysis will generate a benefit cost ratio for each natural resource individually, sequentially, and cumulatively. Sequentially and cumulatively, the different resources have an assumed order of development and the benefits to cost ratio will increase as more resources partake in the freight services. Stated differently, the benefits will increase until the railroad reaches maximum capacity. The resulting analysis will produce a cost benefit ratio with respect to the volume of entities using the rail service and the freight rate.

2.0 Location and Geologic Hazards

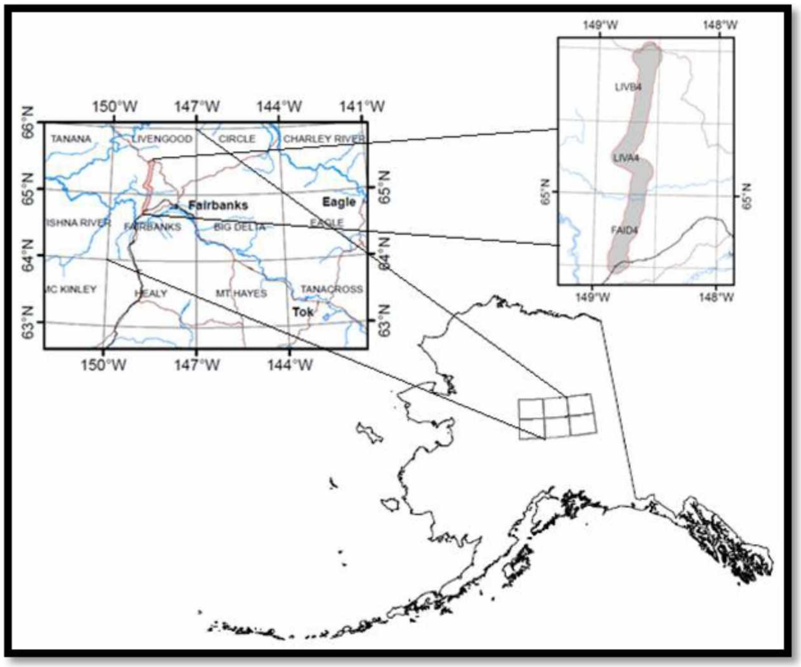

Figure 2.1 Location Map

2.1 General Route Setting

The Dunbar-Livengood route corridor is located in Interior Alaska between Dunbar Siding, along ARRC main line just north of Nenana, and Livengood, Figure 2.1. The corridor generally follows the historic Dunbar-Brooks Terminal Trail. This region has a continental climate, hot dry 90°F summers and cold -40°F winters. Less than 13 inches of water equivalent precipitation is received mostly as snow in this sub arid environment. Previous geologic investigations and work were conducted by: Prindle (1913),Pewe (1948), Wahrhaftig (1965), Weber (1971), Cobb (1973), Brogan, Cluff and others (1975), Pewe (1975), Wahrhaftig, Turner and others (1975), Bundtzen (1982), Forbes (1982), Robinson (1982), Pewe (1982), Fuglestad (1983), Metz (1987) , Karl, Ager and others (1988), Goter (1989), Frost and Stanely (1991), Page, Plafker and others (1995), Wesson, Frankel and others (1999), White, Gunther and others (1989),Wilson, Dover and others (1998), Ridgeway, Trop and others (2002), Reger, Stevens and others (2003), Haeussler, Schwartz and others (2004), and others.

To the south of the region is the active strike-slip Denali Fault, to the north is the Tintina Fault system, to the west it is bounded by the Tolovona River and Minto Lakes, and to the east it is bounded by the Yukon Tanana Uplands (Hall, 1985; Page and others, 1995; Hansen and Dusel-Bacon, 1998; Mihalynuk and others, 1999; Oliver and Dusel-Bacon, 2001; Haeussler and others, 2004; Till and others, 2007). The three significant major small stream crossings are the Chatanika River, the Washington Creek, and the Tolovona River (1973). The topography and drainage are structurally controlled. The topography to the east consists of major north south trending ridges at 1500 to 3000 feet elevation and secondary east west ridges and streams (Wahrhaftig, 1965). The first, second, and third order streams flow west to the Tolovona which flows south to the Tanana. The topography west of the route is a low broad valley marked with thaw ponds, sag ponds, meandering streams, abandoned channels, and oxbow lakes indicating fine grained sediments and discontinuous permafrost conditions.

The proposed Dunbar-Livengood route follows the toe of the slope on the north-south linear feature expressed as a change in topography from hilly to a broad plain, generally reflecting the scarp of the Minto Fault. Minto Flats represents an over 2000 foot down dropped normal fault block (Barnes, 1961; Metz, 1987). The Minto and Livengood creek Faults lay juxtaposed to the Tintina Fault. The Tintina Fault extends from the heart of western Canada and across most of central and western Alaska parallel the Denali Fault. The surrounding area is referred to as the Tintina Gold belt. The fault splits with splays traversing up the Tatalina and Tolovona rivers. The fault continues up the Tolovana River, Livengood Creek, and Myrtle Creek.

2.2 Bedrock Geology

The bedrock description for the general overview traverses from south to north. The bedrock along the Dunbar - Livengood Rail extension corridor progresses from the Yukon-Tanana Upland Schist near Dunbar Siding into the Wickersham Grit, the Livengood flysch sequence of sandstones, shales, dolomite, the Tolovona Limestone, and the Livengood chert. Paleozoic, Mesozoic, and Tertiary intrusive bodies ranging from granite to peridotites intrude the Yukon –

Tanana upland schist. The Livengood sequence is cut with Devonian age dike swarms. Paleozoic, Mesozoic, and Tertiary volcanics and sediments overlie the metamorphic rocks unconformably (Metz, 1987).

The Precambrian metamorphic rocks, the Yukon-Tanana Upland Schist, range from lower green-schist to amphibolite, ecologite, and granulite facies (Metz, 1987). Devonian mafics and ultra mafics have intruded the Yukon-Tanana Upland schist and the Ordovician to Devonian sediments parallel the serpentinite belt as diorite, metadiorite, diabase, gabbro, basalt, metabasalt, greenstone, and pyroxenite.

The Paleozoic sediments consist of Devonian chert , limestone, dolomite, conglomerate, shale, and greywacke (Cathrall and others, 1987). The Tolovona limestone is over thrust and over turned to the north (Wahrhaftig, 1965). The meta-sediments of pyritic black chert, argillite, greenstone, and silicified limestone and dolostone, are host to quartz-calcite veins and quartz monzonite dikes (Karl and others, 1988). Jurassic-Cretaceous flysch units consisting of shale, greywacke and conglomerate unconformably overlie Devonian clastic units (Cathrall and others, 1987). The Cretaceous mineralization is multistage with gold, pyrite, arsenopyrite, stibnite, and other trace amounts of sulfides in veins and disseminated deposits (Klipfel, 2006).

2.3 Surficial Geology

The surficial sedimentary deposits along the Dunbar–Livengood route corridor are well described by Pewe 1975, Karl 1988, Metz 1987 and others. Table 2.1 is reproduced from Pewe (1975) and contains a brief summary of fifteen stratigraphic units defined by Pewe (1975) and correlated units. An illustrated typical valley cross section is contained in the "Quaternary Stratigraphic Nomenclature in Unglaciated Central Alaska" showing the correlation between stratigraphic units (Pewe, 1975).

The Cripple Gravel is a late Pliocene or early Pleistocene brown auriferous, angular gravel, poorly sorted to well stratified, with lenses of silt and sand, overlying the bed rock found on benches and in valley bottoms (Pewe, 1975). The Cripple Gravels are composed of quartz-mica schist, quartzite, chlorite schist, biotite-garnet schist, feldspathic schist, calc schist, graphitic schist, phyllite, slate, quartz monzonite, granodiorite, and granite (Metz, 1987). The Cripple

Gravel, the Nenana Gravel, and the Livengood Gravel units are widely spaced and inferred to be of the same origin (Karl and others, 1988). The Livengood creek gravels have produced over 500,000 ounces of placer gold since discovery in 1914 (Freeman, 2010). This ancient auriferous gravel forms a ten to fifty foot (3 to 15 meter) thick deposit over six miles (10 kilometers) long referred to as the Livengood Bench (Karl and others, 1988). The Fox Gravel is an early or middle Pleistocene tan auriferous coarse angular sandy gravels which overlies the Cripple gravels and bed rock(Pewe, 1975). It is found in valley bottoms overlying auriferous gravels.

The Tanana Formation consists of solifluction deposits along the slopes, is known to contain ice wedges, and overlies the bed rock and Cripple Gravel (Pewe, 1975). It is referred to as slide rock by miners, it consists of unsorted angular weathered bed rock fragments and is overlain by the Fairbanks Loess (Pewe, 1975).

The Dawson Cut Formation is composed of organic silt, forest beds, horizontal logs, and peat layers. It outcrops in valley bottoms and is overlain by the Gold Hill Loess in most locations estimated to be Pleistocene (Pewe, 1975).

Fairbanks Loess is a wide spread, well sorted, tan to grayish, aeolian deposit which blankets the hills. It is estimated to have formed during Pleistocene through Holocene. The Gold Hill Loess is found in valley bottoms, shows folds and contortions and lies unconformably over the bedrock, Cripple Gravel, Fox Gravel, Tanana Formation, and the Dawson Cut Formation (Pewe, 1975). The Gold Hill Loess is considered the valley equivalent to the Fairbanks Loess; well sorted and containing the Ester Ash Bed and the Dome Ash Bed (Pewe, 1975).

The Ester Ash Bed is the oldest ash layer found in both the base of the Fairbanks Loess and the Gold Hill Loess. The Dome Ash Layer is the most persistent ash layer found in Tofty, Livengood, Circle and Fairbanks districts and is composed mostly of glass.

The Eva Formation is Pleistocene age. It is composed of organic silt and forest beds: peat lenses, sticks, logs, and rooted stumps, reworked silt. The Eva Formation unconformably overlies the Gold Hill Loess and is conformably overlain by a gradual contact with the Goldstream Formation (Pewe, 1975).

Table 2.1 Quaternary Stratigraphic Nomenclature from Troy Pewe (1975)

Name	location	time	thickness	materials
		(before present)		
Modern Soil				
Chena Aluvium	Chena alluvium lies unconformably on the bedrock or the Cripple or Tanana Formations	Pleistocene and Holocene	3-100 meters	Fluvial: well sorted river silt, sand, gravel, glacial outwash planes
Engineer Loess		Holocene 10,500 ± 500		Loess
White River Ash Bed	east central Alaska within and near the top of the Engineer Loess sometimes directly below the vegetation or turf mat	Holocene 1400	few millimeters	Ash: three closely spaced layers of pumice glass
Jarvis Ash Bed	near the junction to the Delta and Tanana Rivers the Jarvis Ash Bed is in the Engineer Loess and overlying outwash and glacial till	Holocene between 4200 and 2600	2 - 10 mm	Ash: white vitric ash
Wilber Ash Bed	Fairbanks and northward to Livengood the ash bed lies 1/2 - 1 meter below modern soil, maybe the same as the Jarvis Ash Bed	Holocene less than 4200	5 - 25 mm	Ash: white glass
Ready Bullion Formation	creek valley bottoms and lower slopes unconformably overlies the Goldstream Formation	Holocene less than 10,000	2 meters	Coluvial: retransported silt and forest beds, silt rich in organic material
Goldstream Formation	one of the most wide spread formations in central Alaska composed of reworked silt in valley bottoms, organics and ice rich	Pleistocene (Wisconsinian, >10,000, <39,000)	1 - 30 meters	Coluvial: retransported loess, Ice rich silt, with abundent vegetation

Table 2.1 continued

Chatanika Ash Bed	within and near the top of the Goldstream Formation along the Chatanika River	Pleistocene (Wisconsinian, <14,860 ± 840)		Ash: bedded in organic silt
Eva Formation	unconformably overlies the Gold Hill Loess and is confromably overlain by a gradational contact with the Goldstream Formation	Pleistocene (Sangamon, >56,900)	~1 meter	Organic Silt and Forest beds: peat lenses, sticks, logs, and rooted stumps -- reworked silt
Gold Hill Loess	found in valley bottoms, shows folds and contortions, lies unconformably over the bedrock, Cripple Formation, Fox Formation, Tanana Formation, the Dawson Cut Formation	Pleistocene (Illionian)	1 -20 meters	Loess: tan to grayish tan, well sorted 75 - 85 % between 0.005 mm and 0.05mm in diameter
Dome Ash Bed	this ash has been found in Tofty, Livengood, Circle, and Fairbanks. It is noted as the most persistent ash layer.	Pleistocene (Illionian)	1 -10 cm	Ash: bedded in loess
Ester Ash Bed	oldest ash layer, occurs in the base of the Fairbanks Loess, 2.5 cm above the basal layer is bright pink	Pleistocene (Illionian)	5 - 15 cm with pockets 1 meter thick	Ash: bedded in loess, mainly glass, rhyodacite, and contains andesine

Table 2.1 continued

Fairbanks Loess	most wide spread deposit of Quaternary age in central Alaska that blankets the hills	Pleistocene and Holocene (Illionian through Holocene)	1 - 60 meters	Loess: tan to grayish tan, well sorted 75 - 85 % between 0.005 mm and 0.05 mm in diameter
Dawson Cut Formation	crops out in valley bottoms, overlain in most locations by the Gold Hill Loess	Pleistocene (Yarmouth?)	1 - 3 meters	Organic Silt and Forest beds, peat layers
Tanana Formation	in places the Tanana Formation Grades into the Fox Gravel	Early or middle Pleistocene	1 - 25 meters	Solifuction deposits, poorly stratified and unsorted and angular fractured and weathered bedrock in a silty sandy matrix
Fox Gravel	Valley bottom accumulation of solifuluction of deposits, bones of pleistocene mammals	Early or middle Pleistocene	1 -15 meters	Tan auriferous gravel, poorly to well stratified coarse angular sandy gravel with silt and sand lenses

Table 2.1 continued

Cripple Gravel	Cripple creek gravel overlies the bedrock and is overlain by the Fox and Tanana Formations	Late Pliocene and (or) early Pleistocene	1 - 25 meters	Brown auriferous gravel and solifluction deposits, discontinuous bench deposites, on the bedrock in valley bottoms

The Goldstream Formation is colluvium, ice-rich frozen silt, reworked silt with abundant vegetation, and contains the Chatanika Ash Bed. The Chatanika Ash Bed is a white vitric ash about one centimeter thick estimated as Wisconsinan and occurs in the upper middle of the Goldstream Formation (Pewe, 1975).

The Ready Bullion Formation, estimated to have formed during the Holocene, is colluvial, retransported loess rich in organics, forest beds, found in creek valley bottoms and lower slopes unconformably overlying the Goldstream Formation.

The Engineer Loess, formed during the Holocene, contains the Wilber Ash Bed, the Jarvis Ash Bed, and the White river Ash Bed and unconformably overlies the Goldstream Formation. The Engineer Loess is weakly bedded to unbedded (Pewe, 1975). The Wilber Ash Bed, composed of white glass, lies eighteen inches to three feet (½- 1 meter) below the modern soil from Fairbanks to Livengood and may be the same as the Jarvis Ash Bed. The Jarvis Ash Bed contains a white vitric ash, mapped near the junction to the Delta and Tanana Rivers in the Engineer Loess and overlying outwash and glacial till found under two meters of loess. The White River Ash Bed contains three closely spaced layers of pumice glass in east central Alaska within and near the top of the Engineer Loess sometimes directly below the vegetation or turf mat (Pewe, 1975).

The Holocene Chena Alluvium lies unconformably on the bedrock or the Cripple Gravels or the Tanana Formations with fluvial, well sorted river silt, sand, gravel, glacial outwash planes.

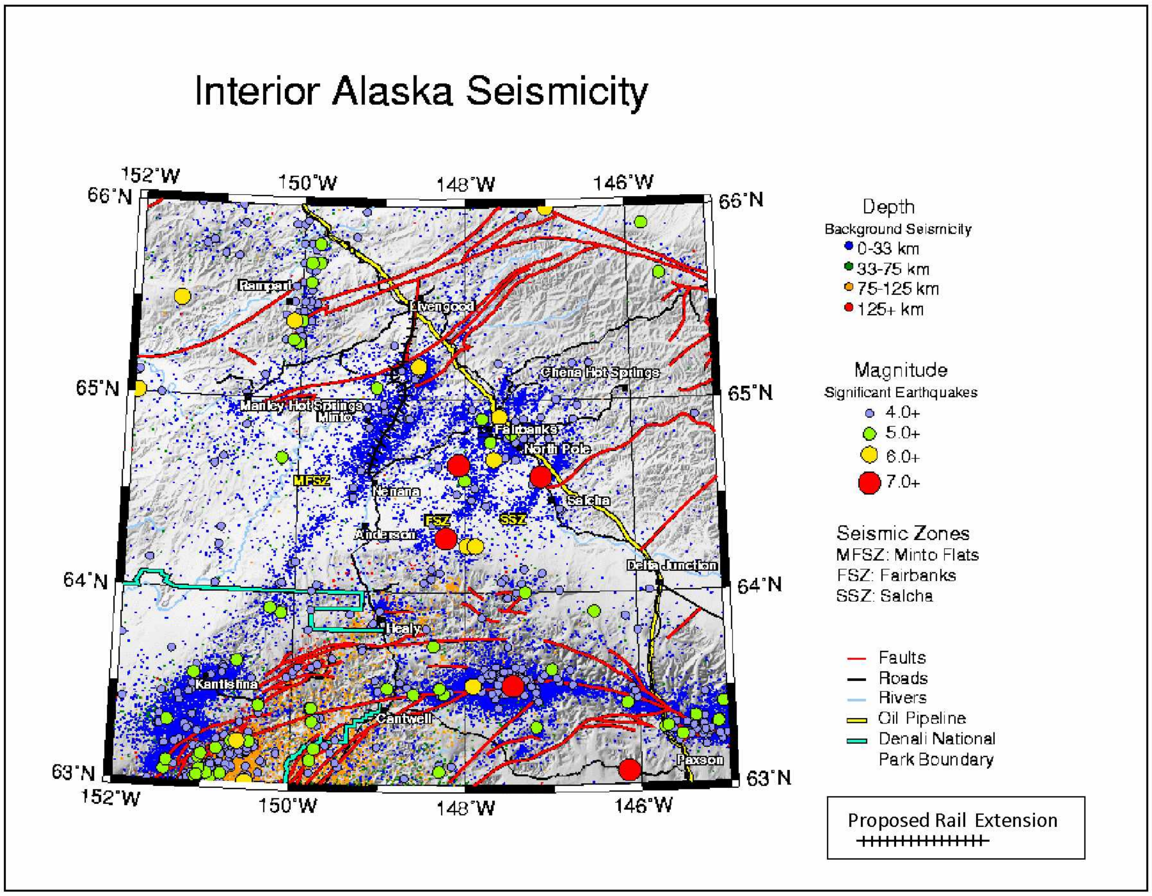

Figure 2.2 Seismicity displayed is from 1904 to 1/31/2005 (Fox, 2006)

2.4 Seismicity

Seismicity is a significant concern in interior Alaska. The seismic events are generally related to the deep Pacific plate thrusting under the North American plate, the strike slip motion along the Denali and Tintina faults systems, and more shallow stress relief along the normal faults; however, little is known about the geologic structures and further work is recommend beginning with these references (Brogan and others, 1975; Hickman and others, 1977, 1978; Metz, 1982; Pewe, 1982; Robinson, 1982; Combellick, 1984; Espinosa, 1984; Hall, 1985; Pulpan, 1988; Goter, 1989; Plafker and Berg, 1994; Page and others, 1995; Hansen and Dusel-Bacon, 1998; Wesson and others, 1998; Mihalynuk and others, 1999; Wesson and others, 1999; Haeussler and others, 2004; Till and others, 2007). The seismicity displayed in Figure 2.2 is the recorded events from 1904 to January 2005 (Fox, 2006). The record contains four events greater than magnitude seven, twelve events greater than magnitude six, and many smaller events along the Minto Flats lineament. The railroad corridor lies between the active Denali and Tintina Fault systems among a clockwise rotational block faults with the proposed alignment following the Minto Flats and the Myrtle Creek lineaments (Pewe, 1982; Page and others, 1995).

2.5 Aufies/Icings

The long winter season in Interior Alaska freezes many of the rivers solid and fastened to the ground. With the rivers frozen ground fast, the ground water head often exceeds the river ice surface elevation and the ground water flows above the ice through cracks. This is referred to as 'Icings' or aufeis. Icing occurrences have been measured over 30 feet thick, often plugging culverts, covering road surfaces, and damaging facilities, see the USGS open file report 75-87.

2.6 Frozen Ground

Interior Alaska presets some of the most challenging climate and ground conditions to engineers. The frozen ground is protected by the passive evaporation and shading by the ground cover which are in equilibrium with the summer heating and winter freezing cycles. The differential thaw settlement and creep in frozen soils create significant hazards and challenges for railroad alignments in cold climates regions, as noted in the recent Qinghai-Xizang Railroad (Qingbai and others, 2007; Qihao and others, 2008; Qin and others, 2009). Understanding the subsurface in-situ frozen materials is critical for a maintaining the integrity of vertical and horizontal rail alignments. Creep in permafrost soils near the critical thermal boundary of thawing is significant for understanding the foundation dynamics for structures built over frozen soils. The parameters for this rail extension call for less than or equal to three degrees of curvature, and grades not to exceed one percent, to maintain travel velocities of 127 kilometer per hour (79 mile per hour). The current climate conditions indicate a thawing index which would thaw the ground, greatly reducing the bearing capacity and causing thaw settlement. Using surface geologic unit descriptions, thaw settlement data from similar terrains and deposition structures, creep research and case studies within the rail corridor study area, the estimates for potential mean thaw settlement hazards are 0.3 ± 0.013 meters during the first year and long term effects of 0.4 to 4.9 meters settlement over 2 to 7 years. The mean combined thaw and creep rate differential settlement ranges from 0.347±0.016 meters settlement during the first year, to 1.658 ±0.064 meters for the standard mean sample after four years, and 5.321±0.112 meters for ice rich soils after 7 years. This is not the focus of this thesis, only a note of potential hazards from literature review and comments of additional sources for further study (Bear, 1972; Kreig and Reger, 1982; Fuglestad, 1983; McHattie and Esch, 1988; Instanes and others, 1998; Goering, 2003; ASTM, 2004; Joint Departments of the Army and Air Force USA, 2004; Cheng, 2005; Quan and others, 2006; Yu and others, 2006; Xuefu and others, 2007; Cheng and others, 2008; Shur and Kanevskiy, 2010; WRCC, 2010; Wu and others, 2010).

3.0 History

3.1 Brief History of the Alaska Railroad

The ARRC vision is “Building a great railroad across a great land” and the ARRC mission is to “Be profitable while delivering safe high quality service to our freight, passenger, and real estate customers. Foster the development of Alaska’s economy by integrating railroad and rail belt community development plans” (ARRC, 2010c).

The ARRC begins in Seward and extends north 470 miles (756 km) to Fairbanks and with construction moving forward on the 100 mile (161 km) rail extension to Delta Junction. The railroad crosses the Chugach and Alaska mountain ranges to link interior Alaska with tidewater. Following is a brief history of the ARRC (ARRC, 2010b).

In 1903 Alaska Central Railway built the first 50 miles of railroad from Seward Alaska extending north using the same methods of cut and fill as the transcontinental railroad without wasting any of the excavated material (Fuglestad, 1983). The engineers did not understand the nature of thaw settlement or frost heave and the use of unclassified materials have contributed to the current operation and maintenance cost. In 1907 Alaska Central Railway went bankrupt and March 12th, 1912 the US congress agreed to fund the construction and operation of a railroad from Seward to Fairbanks at a cost of \$35 million (ARRC, 2010b). On June 1917, the Tanana Valley Railroad, a 45-mile (72.4 km) narrow gauge railroad was purchased and on July 15, 1923 Warren G. Harding drove the golden Spike marking the completion of the Railroad in Nenana. On August 2nd President Harding died of food poisoning during his return trip to San Francisco (ARRC, 2010b). In 1938, the Railroad brought its first profitable year and during 1940-43, World War II brought large profits. Two large tunnels were built for rail access to Whittier in 1943 and in 1944 Whittier opened as a second railroad port. The March 27, 1964 earth quake caused \$30 million in damage. On January 14, 1983, President Ronald Reagan signed the transfer of the Alaska Railroad to the state of Alaska and the transfer ceremonies were held January 5, 1985 in Nenana and Seward. On October 12, 1986, a 100 year flood event covered the track with mud and caused \$3 million in damages with a 13 days lost service (ARRC, 2010b). In 1999, the Whittier tunnel opened to vehicular traffic and the rail shuttle service between Whittier and

Anchorage ended (ARRC, 2010b). In August 2004, the Palmer South Station opened the new park and ride facility initiated by the Alaska State Fair. On August 2006, flooding damaged the rail and interrupted highway transport service between Anchorage and Fairbanks. Repairs were completed in less than 48 hours (ARRC, 2010b).

3.2 History of Mining in Livengood

Placer gold was first discovered on Livengood Creek in 1914, the mining community of Livengood was established and more than 500,000 troy ounces (15.6 tonnes) of placer gold were produced over the last century. During the 1950's, trenching operations were conducted to search for lode gold within the area and Money Knob Project was determined to be the most likely lode source for the placer deposits on Livengood Creek. The majority of the early structural and geological work was undertaken by the USGS in 1967, which was followed up by approximately ten Alaska Department of Geological and Geophysical Survey mapping and sampling programs between 1971 and 2004 (Klipfel, 2006). It is estimated that nearly 300,000 troy ounces (9.33 tonnes) of placer gold remain within the Livengood Bench. Exploration on the property by major mining companies began with Homestake in 1976, followed by Alaska Placer Development in 1980, Occidental Petroleum in 1981, AMAX from 1990 through 1991, Placer Dome, 1995-1997, Cambior in 2000, Anglo Gold Ashanti from 2003 to 2005, and at present, International Tower Hill Mines (Klipfel and others, 2009).

Placer Dome had made some fairly extensive exploration work, primarily on the northern side of Money Knob and within the Livengood Creek Valley, though little data is actually available. Cambior conducted geochemical soils surveys in 2000 which indicated anomalous zones within the area. Anglo Gold Ashanti conducted drilling programs from 2003 through 2006, producing results which identified favorable and encouraging mineralization over the extent of Money Knob and onward to the east. International Tower Hill acquired the properties in 2007 and embarked on an aggressive exploration program which has resulted in hundreds of drill holes and considerable data indicating a significant gold resource of 6.9 million ounces (215 tonnes) and an additional inferred 1.4 million ounces (43.5 tonnes) (Pontius, 2010b).

4.0 Methods and Models

4.1 Freight Modeling Summary

The freight model was created and analyzed in sequential stages as each of the potential resources are likely to be developed, since not all of the limestone, timber, tourism and mineral projects will be developed simultaneously. The freight loads were estimated by reviewing data from current mining operations, timber harvest resource estimates, and the necessary mining re-supply goods.

4.2 ARRC Model

The ARRC model is based on recovering the capital cost and operating costs through the freight revenue stream. The basic parameters for the economic analysis are: a 30 year life cycle, an analysis at five percent and seven percent return on investment, and providing both freight and passenger service. Literature research provided the estimates of capital, operating costs, and potential freight revenue resources (Boland and others, 2007a, b, c, d; Boland and others, 2008; ARRC, 2010b; Brooks and others, 2010; O'Leary, 2010). It is noted that the 30 year life for rail road infrastructure is extremely conservative; many railroad infrastructures are over one hundred years old. The capital cost of $300 million is based on: $5.5 million per mile new construction, $1.3 million per mile upgrades, and $6.7 million per Diesel Motive Unit (DMU) (Boland and others, 2007b; Carr, 2010). This preliminary study has identified 60 miles (97 km) of rail upgrades and 40 miles (64 km) of new rail. The operating costs of $0.057 per ton-mile for freight, $0.19 per ton-mile for passenger service, and $40,000 per mile per year of Federal Subsidies for passenger rail service; are based other similar study areas and projects (Boland and others, 2007b; Boland and others, 2008; ARRC, 2010a; Carr, 2010; O'Leary, 2010). The rail design specifications are for three (3) degrees, of curvature and one (1) percent grades to sustain travel speeds of 79 mile per hour (127 kph) for a one and one half (1.5) hour commute from Fairbanks to Livengood (Boland and others, 2007c; Carr, 2010).

U.S. Railcar DMUs are recommended for the employee passenger shuttle service. The DMU's are self-propelled passenger rail cars produced by US Railcar. DMUs are capable of towing other passenger cars and working in series (Railcar, 2010). The daily service would decrease capital costs of a man camp, increase employee transportation safety, add transportation service to rural communities, allowing miners to return home each day after work, and contribute to quality of living. The mine employees will require two 100 passenger DMUs to transport up to four 74 passenger rail cars. The transport estimate assumption is for two thirds of the work force during the day shift and one third during the night shift, with eight percent extra seat space.

4.3 Initial Rail Operation Cost Estimates

The initial operating cost estimate of $0.02 per ton mile for freight and the $0.015 per passenger mile operation cost was estimated based on the ALCAN report (Boland and others, 2007b). The ALCAN report may not include back haul and the operation costs are estimates for a larger tonnage and longer haulage rail system, 1700 miles (Boland and others, 2007d).

The capital costs, operating costs, and federal grant benefits were all brought into present value terms and summed. The resulting sum was projected as an annual payment over 30 years and divided by the estimated annual tonnage of freight and passenger transport. The average number of passengers per transport shuttle was divided by the shuttle train weight to find 0.839 passengers per ton of passenger car. Using the initial re-supply freight load for Money Knob Project at 1180 tons (1070 tonnes) per day and 1223 passengers split over two shuttles at 0.839 passengers per ton the estimated rate to recover the capital and operating cost over 30 years at interest rates of five percent and seven percent IRR is $0.12 and $0.14 per ton mile respectively. These rates are inclusive of both passenger and freight transport.

The accuracy of the above freight and passenger operating costs of $0.02 per ton-mile were questioned upon review of pertinent ARRC operating costs. Further literature review brings new results based on the ARRC 2009 financial statements and fact sheets and confirmed later with the Yukon Short Track Report (Boland and others, 2008; O'Leary, 2010).

4.4 Final Rail Operation Cost Estimates

The operating revenues for the ARRC consist of 59 percent freight, 15 percent passenger, 0.5 percent other, and 25 percent grants, see Table 4.1, (O'Leary, 2010). Using a weighted average, the grant and other revenue was distributed proportionally between the freight and passenger operating revenue. The freight operating expense and revenue are divided by the tons of freight and two-thirds of the mainline mileage. The passenger operating expense and revenue is divided by the number of passengers and two-thirds the mainline mileage. Two-thirds the mainline mileage is the dividing factor because it is estimated most freight and passengers will travel two thirds the rail mainline mileage.

The ARRC transported 6.16 million tons of freight in 2009 with revenues of $84.9 million and expenses of $109 million (ARRC, 2010a; O'Leary, 2010). The freight revenue is adjusted with a weighted grant disbursement based on the 59 percent freight and 15 percent passenger revenue. The adjusted freight revenue, $114 million, is divided by the 6.16 million tons. The resulting $18.61 revenue per freight ton is divided by the two-thirds the main line length. The ARRC main line is 467 miles (752km) long. The result is the unit operating revenue of $0.059 per ton-mile. In a similar fashion, the $109.9 million in freight operating expenses are divided by the 6.16 million tons freight and two-thirds the mainline distance, 311 miles(ARRC, 2010a; O'Leary, 2010). The resulting freight operating cost is $0.057 per ton-mile as seen in Table 4.1.

The ARRC passenger service generated $21.5 million revenue with $28.0 million in expense while transporting 470,786 passengers during 2009 (ARRC, 2010a; O'Leary, 2010). The ARRC main line is 467 miles long. Using a weighted distribution, the grant revenue was distributed proportionally between the freight and passenger operating revenue. The adjusted passenger revenue is divided by the 470,786 passengers. The resulting $61.96 revenue per passenger is divided by two-thirds the mainline length. The result is a passenger-mile operating revenue of $0.20. In a similar fashion, the $28 million in passenger operating expenses were divided by the 470,786 passengers and two-thirds the mainline distance. The resulting passenger operating expense is $59.51 per passenger and $0.19 per passenger-mile.

Table 4.1 ARRC 2009 Annual Operating Revenue and Expenses

Operating					
Revenue			$ rev per	$ rev/unit-mile	
59%	freight	$84,939,000	$18.61	$0.0598	ton
15%	passenger	$21,455,000	$61.96	$0.1976	passenger
0.5%	other	$704,000			
25%	grant	$36,515,000			
	total	143,613,000			
Expense					
	freight	$109,915,359	$ exp per	$ exp/unit-mile	
	passenger	$28,017,641	$17.84	$0.0574	ton
	other		$59.51	$0.1898	passenger
	grant				
	total	$137,933,000			
		$137,933,000	miles	467	
			2/3 miles	311	

The unit mile rate is figured at two thirds the mainline rail mileage.
This method encompasses the backhaul expense in the freight rate.

4.5 Freight Sources

The freight loads were estimated by reviewing data from current mining operations and the necessary mining re-supply goods. The railroad freight model begins with the freight supply and employee transport estimate for ITH. The copper porphyry prospect at Shorty Creek has the next potential for development. The next probable freight resource to reach development is the Limestone prospect at Globe Creek. The next freight estimate is for the bulk tonnage of metals and re-supplies freight for the 417 metal mineral prospects in the Alaska Resource Data Files (ARDF) in the Dunbar Livengood Rail Extension corridor. The bulk tonnage is modeled according to the ARDF noted model deposit type and the respective Cox and Singer Model grade and tonnage distributions at the tenth, fiftieth, and ninetieth percentiles. Tourism was estimated at five percent of the volume flow of Denali National Park. The timber resources of the Tanana

Valley State Forest are included in the Freight tonnage analysis. The volume and tonnage of north bound truck freight which could be diverted to Livengood at this time is not estimated.

4.5.1 ITH, Money Knob Project Freight Model

The initial modeled freight source is the Money Knob project. The in-bound freight loads for ITH are modeled after similar open pit, truck shovel, mining operations. Figure 4.1 contains the flow chart for the mine model. The resulting freight resupply load is in pounds of consumables per ton mined. The pounds of consumables vary with the mine model and the tonnage distribution between the mill and heap leach circuit.

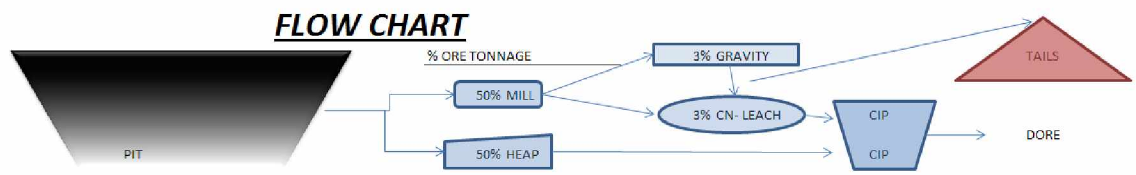

Figure 4.1 Base Case Mine Model Diagram Ore Flow Chart.

The parameters for the ITH perspective study use several scenarios based on different mine life, tonnage, and resource estimates. This follows the pattern similar to the PEA released by ITH (Pontius, 2010i). This study considers four different scenarios. All four scenarios use the same base premise: open pit truck/shovel operation, run of mine valley fill heap leach, and a milling circuit. The mine life ranges from 16 to 36 years based on input nominal mine tonnages. The tonnage is varied from 184,000 tons per day, the tonnage used in the PEA, to 410,000 tons per day, the volume of Barrick Goldstrike (Barrick, 2000; Pontius, 2010f). The resource estimates ranges from 10.6 million ounces to 19.8 million ounces, see Table 4.2, (Pontius, 2010b, f). The visible gold in the core indicates a mill circuit with gravity recovery and an agitated leach circuit (Pontius, 2010c).

Table 4.2 ITH Livengood Resources June 2010 (Pontius, 2010b)

June 2010 Livengood Resources (at 0.7 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.7	201.7	1.07	6.9
Inferred	0.7	39.9	1.06	1.4
June 2010 Livengood Resources (at 0.5 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.5	408.6	0.83	10.9
Inferred	0.5	94.4	0.79	2.4
June 2010 Livengood Resources (at 0.3 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.3	788.9	0.62	15.7
Inferred	0.3	229.1	0.55	4

The first ITH mine scenario or base model is defined as a 184,086 tons per day (167,000 tonnes) ore and waste, open pit, truck shovel operation with 1:1.07 ore to waste stripping ratio after literature review of the ITH press releases, see the Appendix. The mine life is estimated at 21 years; however, the project indicates a longer mine life. This model splits the ore approximately 50/50 between the milling circuit and heap leach.

Table 4.3 Mine model grade and tonnage inputs

June 2010 Livengood Resources				
	Gold Cutoff (oz/ton)	Short tons	Mean Gold (oz/ton)	Ounces
Mill	0.0204	266,318,413	0.0312	8,298,529
	0.0146	554,462,589	0.0240	13,301,220
Net Heap Leach	0.0088	855,834,502	0.0134	11,478,143
Resource Total	0.0088	1,122,152,915	0.0176	19,776,672

The second, third and fourth ITH mine scenarios split the ore tonnage with a mill grade cutoff of 0.02 troy ounces per ton (0.7 ppm) and a heap leach cutoff of 0.0088 troy ounces per ton (0.3 ppm) based on the cutoff grades from the published mine data (Chadwick, 1995; Golder and Associates, 2004; Briggs, 2005; Kerr, 2006; McGroarty, 2006; Price and others, 2006; Pontius, 2010f, i). Table 4.3 contains tonnage estimates for the mill and heap leach derived from Table 4.2. Either the mine life or the mining rate is fixed in the second, third and fourth scenarios for comparisons of the mine models and the effects of mining rate on perspective freight rates.

The tonnage of mine, heap leach, and mill consumables are estimated using data from other large open pit gold mines with milling and heap leach operations. The data comes from different years with different annual rates; thus, the data sets were carefully processed within the year specific data. The consumables data is made equivalent to produce outputs of pounds of consumable per ton mined, milled, or leached. The lime consumption, for Money Knob Project, is based on bottle roll tests and the lab analysis indicates four pounds of lime will be required per ton of ore (Metz, 2010). Table 4.4 contains the abbreviated itemized list of consumable estimates in pounds per ton, and daily and weekly estimates for totals tons of freight. The data for the tonnages of consumables is based on the published data collected from similar type open pit gold mines using milling and heap leach recovery operations (Singer and others, 1998; Barrick, 2000; Goldstrike, 2005; Kerr, 2006; Knox, 2006; McGroarty, 2006; Penwarden, 2006; Kinross, 2007; Singer, 2007; Henderson and others, 2008; Kinross, 2008b, a, 2009; Klipfel and others, 2009; Leinart, 2009; Kennecott, 2010).

Table 4.4 Mining Consumables and Passenger Volume Estimates

Money Knob Project: ITH Livengood Project				
Pit	184,086	tons/day	167,000	tonne/day
Ore	88,930	tons/day	80,676	tonne/day
Waste	95,156	tons/day	86,324	tonne/day
Heap	44,465	tons/day	40,338	tonne/day
Mill	44,465	tons/day	40,338	tonne/day
Mining				
	lbs/ton mined	lbs/day	tons/day	tons/week
Fuel	1.3707331	252333	126	883.164699
Electricity				
Lubricants				
Grease	0.0179353	3302	2	12
Antifreeze	0.0015834	291	0.15	1.02
Oil	0.0314841	5796	3	20
Tires	0.0611610	11259	6	39
Blasting agents	0.4591250	84518	42	296
Drill bits	0.0008519	157	0.08	0.55
Drill Steel	0.0000591	11	0.01	0.04
Equipment	0.0130000	2393	1	8
Milling costs				
Electricity				
Milling rate				
operating cost				
Balls	1.3555634	60275	30	211
Liners	0.3357440	14929	7	52
Belt	0.0032433	144	0	1
Heap Leach				
Loading rate				
Cyanide	0.0466349	2074	1	7
Recovery				
Carbon	0.0236355	2102	1	7
Cyanide	0.0466349	4147	2	15
Lime	4.0000000	355722	178	1245
G&A Taxes				
Sundry (10%)	0.8293213	152666	76	534
	8.5967102	952119	476	3332
Passenger transport~				
			employees	
employees/ton/day	0.002880418		530	

Table 4.5 Base Case Railcar Estimate for Money Knob Project

Railcars per Year					
	tanker	flat	tanktainer	sidedump	Car
Fuel	542				Tanker
Grease		9			Flat
Antifreeze			1.0		Tanktainer
Oil			25		Tanktainer
Tires		35			Flat
Blasting agents			186		Tanktainer
Drill bits		2			Flat
Drill Steel		0			Flat
Equipment		1			Flat
Balls				105	Sidedump
Liners		26			Flat
Belt		0			Flat
Cyanide		14			Flat
Carbon		9			Flat
Lime				623	
Sundry (10%)		534			Flat
Employees		2749			

				2112	total cars /year		
Supplies	42	50 car trains per year		0.8	supply trains a week		
Passenger	2	per day	2	DMU		3	cars

The number of employees was estimated for two twelve hour shifts per day. The ratio of mine employees to tonnage uses two data sources with mining rates of 160,000, and 425,000 tons per day with 425 and 1400 employees respectively (Briggs, 2005; Kinross, 2008a). Using a linear trend between the two data points, the average is 0.00288 employees per ton per day. This model assumes two thirds of the work force will work during the day shift and one third will work during the night shift to estimate the volume of employee transport. Most of the human resources and engineering departments will work days. The employee and passenger transport would occur twice each day to coincide with shift change. Two 100 passenger DMUs and three

74 passenger railcars are necessary to transport the 354 employees for the day shift.

Table 4.5 contains estimates of the number railcars of consumable re-supply freight per year at approximately one 50 car freight train per week. The car count is based on maximum volume and tonnage per freight type shipped. For example, the author calculated the maximum volume of antifreeze needed for the Money Knob Project model per year and divided the volume by the capacity of a tanktainer. The maximum cargo weight per shipping container is also considered to determine whether the limiting factor was the commodity weight or volume. Two tanktainers ship per railcar. The result is 1 railcar carrying two tanktainers of antifreeze per year. The railcar count for the other consumables is figured similarly in Table 4.5. The resulting freight re-supply load is approximately 8.6 pounds of consumables per ton mined depending on the ore tonnage distribution between the mill and heap leach processes. The ITH mine model is defined in more detail in section Livengood Money Knob Project Mine Model.

4.5.2 Shorty Creek Project

The Shorty Creek freight model uses the outbound ore concentrate and in bound re-supply as freight inputs. The freight potential is modeled according to the tenth, fiftieth, and ninetieth percentile of Cox and Singer Ore Deposit type Model 21a for mine tonnage for a copper-molybdenum-gold porphyry deposit type. The Cox and Singer Model is based on the historic mine grade and tonnage data from 55 different mine types (Cox and Singer, 1986). The tonnage and grade data is plotted on cumulative probability plots by mine model type where the large tonnage deposits are the larger percentiles and the smaller tonnages are the lower percentiles. The freight is assumed to be ore concentrate being shipped to the smelter. The freight tonnages for the tenth, fiftieth, and ninetieth percentiles are analyzed individually to estimate the freight rate at the different probable mine outcomes. Further explanation of the mineral prospects model is below in Ore Prospect Tonnage Model. The freight tonnage potentials are combined for the Money Knob Project and Shorty Creek Projects to create freight rate estimates. The combined freight tonnages are further discussed below in Rail Freight Model Results.

The basic Shorty Creek mine model assumptions are: a thirty year mine life for the ninetieth percentile, twelve year mine life for the fiftieth and tenth percentile, and five percent of the freight export tonnage is freight re-supply tonnage. The ninetieth percentile Shorty Creek tonnage model is used throughout the remaining model based on indications in literature review findings: the large magnetic anomaly mapped, rock samples collected, and stream sediment pan sample concentrates collected by Alaska Division of Geological and Geophysical Surveys (Albanese, 1982b, c, a; Southworth, 1982; Cady, 1991; Burns and Liss, 1999; Freeman, 2010).

Using the Cox and Singer Model types and data, the ninetieth percentile copper-molybdenum-gold porphyry deposit type generates 808,000 tons per year of ore concentrate with the respective freight re-supply of 40,000 tons per year of mine consumables. The 50th percentile deposit type should generate 290,000 tons per year of ore concentrate and consume 14,500 tons per year of mine consumables. The 10th percentile deposit type should generate 42,700 tons per year of ore concentrate and need 2100 tons per year of mine consumables (Cox and Singer, 1986; Singer, 1996; Singer and others, 2002).

4.5.3 Globe Creek Limestone Project

The Globe Creek model is based on three different potential products: limestone, agricultural lime, and Portland cement. The lime and/or Portland cement development depends on the access to low cost power for the intense heat needed for production. The first step in the Globe Creek model uses a review of a previous quarry design and economic analysis report by Preston Miller (2005).

The lime production rate is estimated at the consumption rates for the large mines in interior Alaska; Fort Knox at 100 tons per day, Teck Pogo at 100 tons per day, and Money Knob Project at 200 tons per day (Metz, 2010). The small size of the lime operation lends itself to trucking the re-supply and lime freight to end users (Metz, 2010). Additionally, it is estimated twenty tons per day of fertilizer will be produced from the limestone and 100 tons per day worth of stone production. The lime kiln could also be used to produce light weight aggregates from the adjacent shale formations.

A Portland cement plant is a large scale project and interdependent on the development of a low cost power source (natural gas pipeline, coal), low transportation costs, and the market or a large project such as the Susitna Dam project. The base economic scale for a Portland cement plant starts at 2400 tons per day. The natural gas pipeline could provide a clean, low cost power source for the Portland cement kiln. The Susitna Dam project will use approximately 1200 tons of Portland cement per day for eight years during its construction (Metz, 2010). The Susitna Dam project's Portland cement requirement will generate the capital recovery for the Globe Creek Portland cement plant. After the dam construction is completed the Portland cement can be marketed to the Pacific Rim (Metz, 2010). The Dunbar to Livengood Rail extension, with a spur line to Globe Creek, is essential to provide low cost transportation for the Portland cement to both a batch plant near the Susitna Dam Project and to tide water for the global market.

4.5.4 Probable Prospects

There are 10,000 metallic mineral prospects on record in the Alaska Resource Data Files, ARDF, 417 which lie inside a 50 mile radius of the Dunbar Livengood Rail Corridor Extension and south of the Yukon River. The potential resource freight tonnage and gross metal values are estimated for the tenth, fiftieth, and ninetieth percentiles grade and tonnage model types used by Cox and Singer Models for each of the 417 prospects, see Figure 4.2 (Cox and Singer, 1986). Figure 4.2 is a USGS overlay of pick axes marking prospects on Google Earth Imagery.

Freeman and Schaefer (1996) used the historic mining activities and geologic structures to assign a deposit type and a mine model based on Cox and Singer's Mineral Deposit Model. Cox and Singer (1986) assembled data for tonnage and grade by mine type in their Mineral Deposit Model, United States Geological Survey Bulletin 1693, using historic mine data to form probability distributions for mines by type, geologic description, and surface or underground. The historic mine data was plotted and curve fit to find a statistical distribution. The tonnages and mean grade were extracted from the USGS Survey Bulletin 1693 distribution curves to model the potential tonnage and gross metal value outputs at the tenth, fiftieth and ninetieth percentiles. The data is cataloged in a database library for a computer program. The gross metal tonnage for each prospect is converted to bulk concentrate tonnage to determine the outbound shipment tonnage and an additional five percent of inbound freight tonnage is estimated as consumables for mine re-supply.

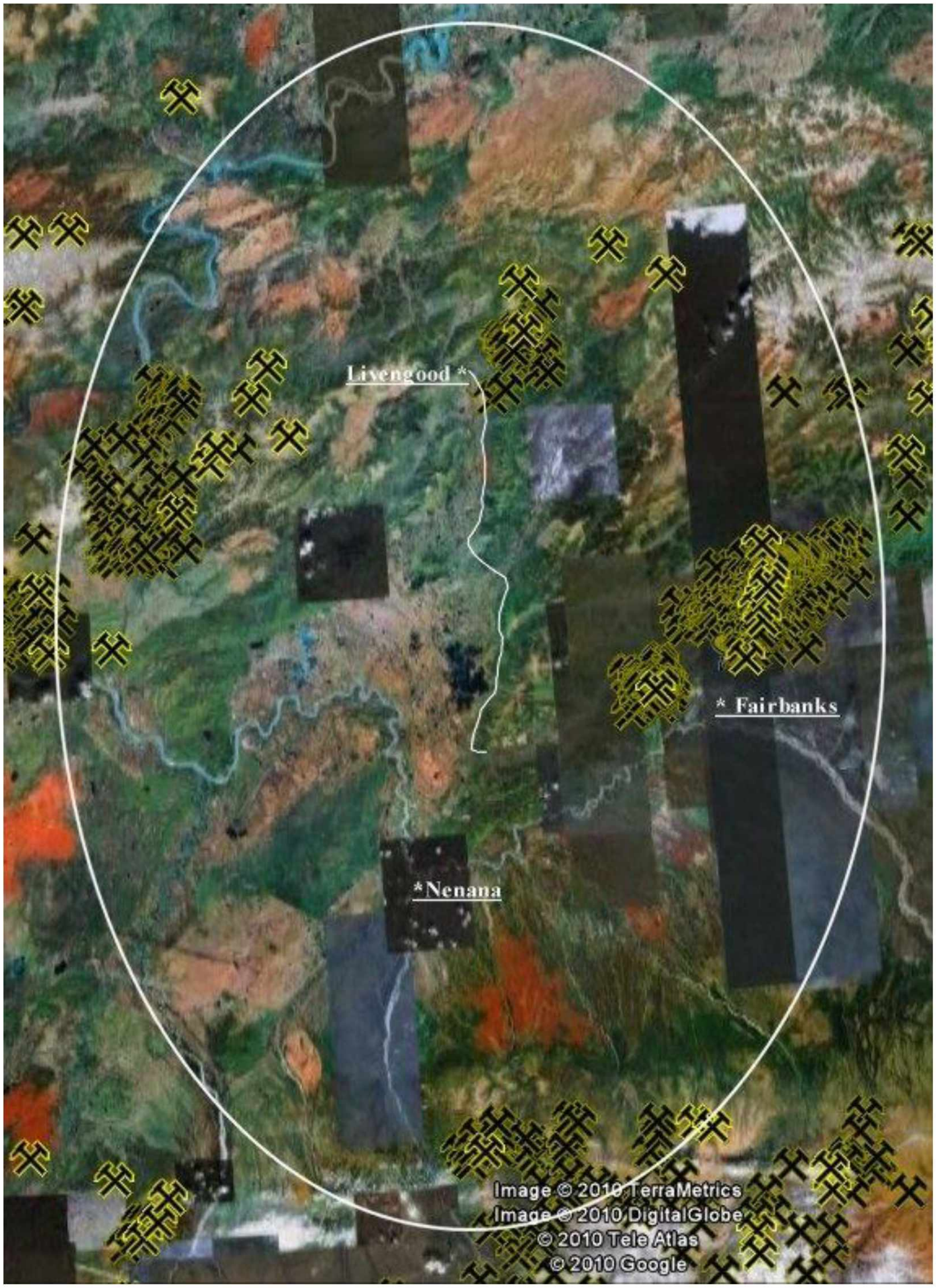

Figure 4.2 Google Earth Image with ARDF Probable Prospects

The development of probability of occurrence is complex relationship of previous occurrence and the geology. Several authors have previously discussed and analyzed the statistical distributions for empirical data and probability of occurrence related to ore deposits: Costa Lima and Suslick (2006);De Geoffroy and Wignall (1970), (1971), (1972); De Geoffroy and Wu (1970); Drew and others (1986); Grunsky (1995); Whitney (1975); Wilson and Harris (1992); and Wilson and Amavilah (2007) . Horkel (1986) discusses the strategic and risky go/stop process of resource exploration to mine development. Brant (1968) sets up an operational equation for return on exploration venture as a method to pre-evaluate a project using: the chance of occurrence, the chance of actual discovery, and the chance of sufficient economic value. Singer (2008) looks at several types of copper deposits as density versus the map scale. Allais (1957) produce a mineral evaluation case study of the North African Sahara with the resulting probabilities of occurrences for deposits of at least $2 million nominal gross value; lest favorable 1 in 1000, median 1 in 500, and most favorable 1 in 250. Bailly (1964) indicated probabilities of 1 in 461 mineral occurrences developing into mines. Conservative estimates for mineral occurrences developing into mine range from 1 in 5,000 to 1 in 10,000 (Missanabie Cree First Nation, 2010; Journal, 2011). Koulomzine and Dagenais (1959) used the 1957 Canadian Mines Handbook and produce the statistics of 1 in 8 or 9 prospects are developed into ore producing mines. Metz and Dixon (1988) and Metz (1994) used probabilities of 5 in 10,000, 1 in 1000, and 1 in 100 for the discovery of major mineral deposits outside known mining districts, within mining districts, and adjacent to operating mines respectively. Brooks and others (2010) constructed a geospatial mineral freight model utilizing the data from Metz (1994) and (2000).

Combining the empirical data for estimated nominal probabilities of mineral occurrence to mine development produces a range of probabilities from 1 in 10,000, to 1 in 1000, to 1 in 100, to 1 in 8 or 9. The rail corridor area is a historic mining district within the geologic structure types. These types of geologic structures are often host to ore deposits indicating a high probability of 1 in 8 prospects being profitable ore producers based on the work by Koulomzine and Dagenais (1959).

Using the work by Cox and Singer (1986) where a ninetieth percentile deposit has a ten percent chance of occurrence and combining it with Koulomzine's and Dagenais' (1959) probability of development returns approximately in one in hundred or one percent combined probability. The following are the even more conservative probabilities of development used for the potential resources within the corridor. The tenth percentile prospect uses a one percent probability of development, the fiftieth percentile prospect uses a one percent probability of development, and the ninetieth percentile prospects uses a one half of one percent probability of development.

The mine models for all 417 metallic mineral prospects (Figure 4.2), at all levels of development, make an assumption of a twelve year mine life. A conservative stripping ratio of 1: 1 was used to estimate the resupply freight load for the probable prospects at five percent of the mine tonnage freight export. The potential resource life, within the corridor, is estimated to be greater than one hundred years; therefore, these parameters generate extremely conservative freight and resource estimates.

4.5.5 Ore Prospect Tonnage Model

The basic ore tonnage and gross metal values estimates are generated using a calculation tool (Metz, 2000) based on data from USGS Survey Bulletin 1693, Mineral Deposit Models by Cox and Singer, for the Dunbar-Livengood Rail Extension Study.

This series of calculation spreadsheets contains multiple individual sheets. First is an executive summary page which collects all of the pertinent tonnage and metal values from the various sheets and presents them clearly and concisely, with a listing of all assumptions made. The second page contains all of the basic inputs such as current metal values, the selected probability of development for each deposit type size, the concentration factor and mill recovery rate for each metal. The third spreadsheet contains all of the ore deposit type model data including the deposit model number, name, related metals, tonnages and concentrations for the 10th, 50th and 90th percentile deposits. Initial calculations are performed on the fourth page. The total tonnage of the deposit is multiplied by the percentage of each metallic ore found in the deposit and added together to give a total bulk ore tonnage. Grams per ton and ppm/ppb are converted to percent. The individual tonnage of each metallic ore is adjusted for the concentration factor and multiplied by the price, then added together to give a gross metal value for the combined metal types found in the deposit. The fifth page reflects the model values from the bulk tonnage and GMV calculations.

Table 4.6 Gross metal tonnage and value for major mineral occurrences

	10th Percentile @ 1% Probability of Development		
	Calculated	Estimated	
Tonage	17,110	17,110	
Gross Metal Value	$84,856,927	$84,856,927	
	*	**	
	50th Percentile @ 1% Probability of Development		
	Calculated	Estimated	
Tonage	140,257	140,257	
Gross Metal Value	$3,205,812,547	$3,205,812,547	
	*	**	
	90th Percentile @ 0.5% Probability of Development		
	Calculated	Estimated	
Tonage	793,846	793,846	
Gross Metal Value	$18,039,286,947	$18,039,286,947	
	*	**	
		Total	
*Calculated Values		Occurrences	417
**Extrapolated Values		Known Types	417
		Unknown	0
Prices Updated	Jan-10		

The model values are adjusted for estimated recovery factors related to underground vs. surface mining. The sixth and final page takes a real world mineral prospect, in this case, an Alaska Resource Data File (ARDF) entry matched to the corresponding model outputs for GMV and tonnage from the fifth page. The number of known and the number of unknown types of mineral occurrences is noted and a value is extrapolated for both along with the actual known total for the known types for comparison with unknown types. In practice, this seems to produce a fairly accurate estimation for anything greater than 40% known deposit types. In discussing the current study, there were no unknown deposit types within the ARDF data, so the actual and estimated GMV and tonnage values are the same.

4.5.6 Timber Resources

The timber resources in the Dunbar Livengood Rail corridor are a potential source of freight revenue. This is only a brief summary of facts from the literature review for the Tanana Valley State Forest resources (Sampson and others, 1988; Zhang and Bliss, 1998; Hanson, 2010). This consists of both dimensional lumber and chip material harvested from the Tanana Valley State Forest (TVSF), an area totaling almost 1.9 million acres. The types of timber found within the region include black spruce, white spruce, tamarack, paper birch, aspen and balsam poplar (Crimp and others, 1997). Similar to other resource utilization estimates, only those portions of the TVSF within an economically accessible radius of the Dunbar-Livengood rail are considered for freight analysis. For this reason, only the Fairbanks Management Area is considered. The Kantishna area falls partially within the corridor but it is not included in this resource estimate.

Table 4.7 Tanana Valley State Forest Fairbanks Management Area Summary

126,112,000	cubic feet of timber (10 year)
518,068,096	board feet of timber (10 year)
41	lbs per cubic foot
258,530	tons per year timber

The freight tonnage and economic value is estimated from the published sustainable yield estimates (Parsons, 2000). The sustainable yield figure is based on a 70 to 100 year rotation period depending on the wood species, and a ten year harvest period. For purposes of clarification, mcf is the abbreviation for net thousand cubic feet and mbf is similarly net thousand board feet (Bond, 2004). A board foot is equivalent to one square foot of a 1-inch-thick board.

Parsons and Associates Inc. estimated that a volume of 134,252 mcf would be available for harvest on a ten year periodic basis. This was published by the Division of Forestry and used to create an Annual Allowable Cut Report which reduced this figure to 126,112 mcf (Jahnke, 2003). The freight tonnage is estimated using an average of the unit weight for birch, aspen, popular, and spruce. The average fresh cut weight of 41 lbs per cubic foot equates to 258,530 tons of potential timber freight. This estimate assumes 100% of the sustained yield is harvested (Table 4.7). Each cubic foot produces 4.108 board feet (Parsons, 2000) or an estimated annual 518,068 mbf at the mill.

The annual resource stumpage value estimates $51,806,810 as revenue to the State of Alaska in forest sales at an assumed stumpage rate of $100 per mbf. The 2008 Alaska Economic Performance Report records $1.26 million in timber sales of 15.5 million board feet, equating to $81 per mbf stumpage sales (Parnell, 2009). The $100 per mbf is a reasonable and conservative stumpage rate estimate. Using an estimated $1.50 per board foot lumber sale price the gross board foot end product value is $77,710,214 per year (Knoles, 2011).

The above estimates differ slightly from the tonnage and volume estimates found in the "Draft Copy Timber resources on state forest lands in the Tanana Valley inventory update 2010", by Hanson (2010) (Table 4.8). The tonnage estimates in this report, Parson's (2000) report, and Hanson's (2010) report differs possibly because the assumed average timber unit weight and not a weighted average unit weight.

Table 4.8. 2010 Timber Estimates

Annual Sustained Yield: Fairbanks Management Area	
6,103,322	net cubic feet per year
126,642	net tons per year
12,781,001	net board feet per year

(Hanson, 2010)

4.5.7 Tourism

Tourism is a potential revenue source with a three year average is 1.6 million visitors to Alaska. The tourism passenger estimate is developed from the Alaska Economic Performance Reports for 2007 and 2008 and the ARRC fact sheets (Palin, 2008; Parnell, 2009; ARRC, 2010a). The visitor influx is classified by transportation method: cruise ship, air, or highway/ferry (Table 4.9). The air and cruise ship visitor numbers are added together for each year, 2006, 2007, and 2008. The row for totals only considers the air and cruise ship passenger traffic, because very few highway tourists are estimated to use the passenger rail services. The air and cruise ship passengers provide a significant portion of the Denali National Park Rail tourism traffic. The ARRC transported 471,000 passengers in 2009, approximately 30 percent of the Alaska tourism influx traffic. The yearly tourism counts are averaged and multiplied by five percent, to produce a conservative estimate of 79,600 passengers, for the Livengood-Dunbar Rail Extension tourism. The main attractions are to enjoy wildlife viewing and possible mine tours. Passenger transport expenses and revenues are estimated at $0.1912 and $0.1990 per passenger mile respectively, based on the ARRC Financial Reports (O'Leary, 2010). The difference between passenger expense and revenue is approximately a five percent return.

Table 4.9 Tourism by method and year for 2006, 2007, and 2008

Year	2008	2007	2006	Average
Cruise Ship	1,000,000	1,029,800	958,900	996,233
Air	597,200	602,100	587,800	595,700
Highway	77,100	82,200	84,800	81,367
Total	1,597,200	1,631,900	1,546,700	1,591,933

4.5.8 Truck Freight

The volume of truck on rail freight transported from Seward and Anchorage is not insignificant, as noted from a brief visual observation of the Fairbanks morning in bound rail traffic. A basic understanding of economics indicates the ARRC must be offering a rail rate at which they generate a profit and offer savings to the trucking industry. It is in the best interest of the ARRC to offer a mutually beneficial freight rate as it increases the tonnage transported by the ARRC, and it lowers the operating cost for the trucking industry. The trucking industry is benefiting from the ARRC services in multiple ways: lower operating costs, less maintenance, less risk, smoother transport, and shorter transport radius.

The volume and tonnage of north bound truck freight which could be rail transported to Livengood at this time is not estimated, personal communication R. Young. A reasonable estimate could be made by counting trucks and multiplying by 30,000 to 50,000 pounds per truck personal communication A. Thompson. Research indicates rail transporting the freight to Livengood at a quarter to half the cost and reducing the trucking haulage distance by one quarter of the distance would reduce the overall shipping costs to the North Slope by twelve to twenty percent depending rail freight rate.

Highway and road maintenance can be directly related to the traffic volume and the tonnage transported. This is part of the reason for weight restrictions as the ground thaws each spring. One side benefit is 100 miles (161 km) reduced cost in road maintenance at $1.3 million per year which Alaska Department of Transportation and Public Facilities (AK DOT&PF) could apply to other roads. This does not indicate closing the road, but less traffic heavy truck traffic will reduce the annual highway maintenance costs. Using the total yearly cost for Fiscal Year 2010, $11.7 million (Maillelle, 2010), and assume twenty trucks per day hauling 40,000 pound (18,100 kg) loads, the cost breaks down to $0.04 per ton for road operation and maintenance.

Highway transport, trucking, is the current transport method for north bound freight out of Fairbanks. Similarly, motor coaches are used to for mass people transport. It is necessary to estimate and compare the highway and rail freight rate costs from the end users perspective, as the final goal in this report is a social cost benefit analysis. A quick estimate of the trucking alternative, moving 30,000 – 50,000 pounds per truck load or using an average net load of 40,000 pounds (18,100 kg) per load at $165 per hour, a five hour minimum, personal communication S. Marrufo, and 75 percent axle weight returns a freight rate of $0.55 per ton-mile for a 100 mile (161 km) haul. The bus shuttle estimate using a daily rate of $1050 returns $0.19 per passenger mile (Molega, 2010). At this time, the rail passenger rate per mile of $0.1990 is about the same as $0.19 for coach transport.

Shifting the highway freight to the adjacent rail infrastructure increases safety and decreases costs for the government, private, and public. In general benefits are the government has less road maintenance costs; the private shippers have lower operating costs and safer travel routes; and the public has increased transport services, infrastructure, lower freight rates, and safer travel routes. The estimated railroad freight rates less than $0.55 per ton mile provide economic benefits for the end user and the shipping service provider.

4.6 Rail Freight Model Results

The ARRC freight model uses the defined freight resources and the estimated potential freight tonnage to determine the potential revenues from each freight source individually and collectively. The railroad capital costs, annual operating costs, federal grant benefits, passenger service expenses, and passenger service revenue were all brought into present value and summed. The resulting sum was projected as an annual payment over 30 years and annual payment is divided by the estimated annual ton-miles of freight. The estimated freight rates to recover the capital and operating cost over 30 years at five percent hurdle rate range from $0.83 to $0.13 per ton-mile depending on the annual freight tonnage. Passenger transport expense is figured at $0.1912 per passenger mile and the revenue is figured at $0.1990 per passenger mile, see Table 4.1.

Table 4.10 contains a summary of the ‘project’ freight sources and the freight rate based on the annual tonnage of freight with 184,086 tons per day Money Knob Project mine model inputs. The freight rates are estimated to recover the capital and operating cost over 30 years for the cumulative ton-miles per year of freight at five percent IRR and seven percent IRR. The first entry, Money Knob Project, is the initial freight source for this study and the freight rates reflect only the freight tonnage for Money Knob. The second entry, Shorty Creek, is figured at the ninetieth, fiftieth, and tenth percentiles for grade and tonnage of a copper-molybdenum-gold deposit type in each individual scenario is added to the tonnage of Money Knob for the different scenarios and perspective freight rates. The third entry, Globe Creek, freight rate is based on the tonnage of Money Knob, Shorty Creek at the ninetieth percentile, and the Globe Creek Limestone Project. The fourth entry, Probable Prospects, includes each of the probabilities added sequentially to the cumulative freight tonnage because this represents a distribution of prospects and the relative freight tonnage. The cumulative tonnage for tourism does not change because the passenger expenses and revenue are accounted for per passenger-mile. The sixth entry, Timber, is cumulatively added to the previous tonnage. At this time there is not an estimate for the tonnage of trucked freight which could be transferred to Livengood over the rail. The freight sources are ordered as to an assumed progression of development. Refer to the sections above for more details.

Table 4.10 Freight rate cumulative summary, ITH at 184,086 tons per day

Freight source	Probability	Rail Freight Rate Estimate			Cumulative
		@ 5% IRR	@ 7% IRR	Freight	
	Percentile	$/ton-mile	$/ton-mile	Ton-miles/year	Ton-miles/year
Money Knob		$0.80	$1.09	17,376,179	17,376,179
Shorty Creek	90%	$0.18	$0.23	84,847,903	102,224,082
	50%	$0.33	$0.43	30,415,872	47,792,051
	10%	$0.65	$0.88	4,479,022	21,855,201
Globe Creek		$0.14	$0.17	91,980,000	194,204,082
Other Probable Prospects	90%	$0.14	$0.16	6,946,152	201,150,234
	50%	$0.13	$0.16	1,227,831	202,378,065
	10%	$0.13	$0.16	149,781	202,527,846
Tourism		$0.13	$0.16	0	202,527,846
Timber (TVSF)		$0.13	$0.15	25,852,960	228,380,806

The Money Knob Project Model indicates 174,000 tons per year freight, one way, and 530 passengers per day split over two shuttles operated 100 miles each way. The initial Money Knob Project tonnage estimated freight rate is $0.80 per ton-mile at a five percent hurdle rate.

Using the Cox and Singer Model types and data, the ninetieth percentile copper-molybdenum-gold porphyry deposit type at Shorty Creek should generate 808,000 tons per year of ore concentrate and need 40,000 tons per year of mine consumables. The addition of 850,000 tons per year to the 174,000 tons per year freight for the Money Knob Project (ITH) reduces the freight rate from $0.80 to $0.18 per ton-mile at a five percent hurdle rate. The freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek at the ninetieth percentile, and the freight re-supply to Shorty Creek.

Using the Cox and Singer Model types and data, the fiftieth percentile deposit type at Shorty Creek should generate 290,000 tons per year of ore concentrate and need 14,500 tons per year of mine consumables. The addition of 305,000 tons per year to the 174,000 tons per year freight for the Money Knob Project reduces the freight rate from $0.80 to $0.33 per ton-mile at a five percent hurdle rate. The freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek at the fiftieth percentile, and the freight re-supply to Shorty Creek

Using the Cox and Singer Model types and data, the tenth percentile deposit type at Shorty Creek should generate 42,700 tons per year of ore concentrate and need 2100 tons per year of mine consumables. The additional 45,000 tons per year to the 174,000 tons per year freight for the Money Knob Project reduces the freight rate from $0.80 to $0.65 per ton-mile at a five percent hurdle rate. The freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek at the tenth percentile, and the freight re-supply to Shorty Creek.

Globe Creek contains a potential of greater than 1.4 billion tons of limestone (Miller, 2005). The estimated freight rates to recover the capital and operating cost over 30 years for the cumulative 194,204,082 ton-miles per year of freight at five percent hurdle rate is $0.14 per ton-mile. The freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek, the freight re-supply to Shorty Creek, the freight re-supply to Globe Creek, and the Portland cement transport out of Globe Creek. Passenger transport expense is figured at $0.1912 per passenger mile and the revenue is figured at $0.1990 per passenger mile.

The freight tonnage for the other potential prospects at the ninetieth, fiftieth and tenth percentiles are added sequentially and cumulatively to the model to reflect the different potential prospects and tonnages: however, the tonnage for the probable prospects at the ninetieth, fiftieth, and tenth percentile does not noticeably decrease the freight rate. This low tonnage is related to the conservative 0.5 to 1 percent probability of development, reducing the total estimate by an order of magnitude.

With the addition of the ninetieth percentile probable prospects, the estimated freight rates to recover the capital and operating cost over 30 years for 201,150,234 ton-miles per year of freight at five percent and seven percent hurdle rate are \$0.14 and \$0.16 per ton-mile respectively. These freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek, the freight re-supply to Shorty Creek, the freight resupply to Globe Creek, the Portland cement transport out of Globe Creek, the ninetieth percentile type deposit re-supply, and the ninetieth percentile type deposits bulk metal freight. Passenger transport expense is figured at \$0.1912 per passenger mile and the revenue is figured at \$0.1990 per passenger mile.

With the addition of the fiftieth percentile probable prospects, the estimated freight rates to recover the capital and operating cost over 30 years for 202,378,065 ton-miles per year of freight at five percent and seven percent hurdle rate are \$0.13 and \$0.16 per ton-mile respectively. These freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek, the freight re-supply to Shorty Creek, the freight resupply to Globe Creek, the Portland cement transport out of Globe Creek, the ninetieth percentile type deposit re-supply, the ninetieth percentile type deposits bulk metal freight, the fiftieth percentile type deposit re-supply, and the fiftieth percentile type deposits bulk metal freight. Passenger transport expense is figured at \$0.1912 per passenger mile and the revenue is figured at \$0.1990 per passenger mile.

With the addition of the tenth percentile probable prospects, the estimated freight rates to recover the capital and operating cost over 30 years for 202,527,846 ton-miles per year of freight at five percent and seven hurdle rates are \$0.13 and \$0.16 per ton-mile respectively. These freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek, the freight re-supply to Shorty Creek, the freight re-supply to Globe Creek, the Portland cement transport out of Globe Creek, the ninetieth percentile type deposit re-supply, the ninetieth percentile type deposits bulk metal freight, the fiftieth percentile type deposit re-supply, the fiftieth percentile type deposits bulk metal freight, and the tenth percentile type deposit re-supply, and the tenth percentile type deposits bulk metal freight. Passenger transport expense is figured at \$0.1912 per passenger mile and the revenue is figured at \$0.1990 per passenger mile.

With the addition of the Timber resources, the estimated freight rates to recover the capital and operating cost over 30 years for 228,380,806 ton-miles per year of freight at five percent and seven percent hurdle rates are \$0.13 and \$0.15 per ton-mile respectively. These freight revenue rate estimates include the freight re-supply for ITH, the ore concentrate out of Shorty Creek, the freight re-supply to Shorty Creek, the freight re-supply to Globe Creek, the Portland cement transport out of Globe Creek, the probable prospects re-supply, the probable prospects bulk metal freight, and the timber freight. Passenger transport expense is figured at \$0.1912 per passenger mile and the revenue is figured at \$0.1990 per passenger mile.

Continuing in a similar fashion, the freight rates are estimated based on different ITH mining rates and resources defined above; at 410,000, 316,000, and 184,084 tons per day in Table 4.11, Table 4.12, and Table 4.13, respectively. The freight rate is directly dependent on the tonnage with an inversely proportional relationship, Figure 4.3. As the freight tonnage increases, the freight rate decreases from the perspective of the ARRC to recover capital and operating costs.

The ARRC internal perspective where the revenue recovers the capital and operating cost is reflected in Figure 4.3. As the freight volume increases the equivalent freight rate decreases. This does not indicate the freight rates the ARRC will charge but is only an analysis of cost recovery at given hurdle rates.

Table 4.11 Freight rate cumulative summary, ITH at 410,000 tons per day.

Freight source	Probability Percentile	Rail Freight Rate Estimate @ 5% IRR $/ton-mile	@ 7% IRR $/ton-mile	Freight Ton-miles/year	Cumulative Ton-miles/year
Money Knob		$0.40	$0.53	37,135,894	37,135,894
Shorty Creek	90%	$0.16	$0.20	84,847,903	121,983,796
	50%	$0.24	$0.32	30,415,872	67,551,766
	10%	$0.36	$0.48	4,479,022	41,614,916
Globe Creek		$0.13	$0.16	91,980,000	213,963,796
Other Probable Prospects	90%	$0.13	$0.15	6,946,152	220,909,948
	50%	$0.13	$0.15	1,227,831	222,137,779
	10%	$0.13	$0.15	149,781	222,287,560
Tourism		$0.13	$0.15	0	222,287,560
Timber (TVSF)		$0.12	$0.14	25,852,960	248,140,520

Table 4.12 Freight rate cumulative summary, ITH at 316,000 tons per day.

Freight source	Probability Percentile	Rail Freight Rate Estimate @ 5% IRR $/ton-mile	@ 7% IRR $/ton-mile	Freight Ton-miles/year	Cumulative Ton-miles/year
Money Knob		$0.50	$0.68	28,624,972	28,624,972
Shorty Creek	90%	$0.17	$0.21	84,847,903	113,472,875
	50%	$0.27	$0.36	30,415,872	59,040,844
	10%	$0.44	$0.59	4,479,022	33,103,994
Globe Creek		$0.13	$0.16	91,980,000	205,452,875
Other Probable Prospects	90%	$0.13	$0.16	6,946,152	212,399,027
	50%	$0.13	$0.16	1,227,831	213,626,858
	10%	$0.13	$0.16	149,781	213,776,639
Tourism		$0.13	$0.16	0	213,776,639
Timber (TVSF)		$0.12	$0.15	25,852,960	239,629,599

Table 4.13 Freight rate cumulative summary ITH at 184,000 tons per day for 36 years.

Freight source	Probability Percentile	Rail Freight Rate Estimate @ 5% IRR $/ton-mile	@ 7% IRR $/ton-mile	Freight Ton-miles/year	Cumulative Ton-miles/year
Money Knob		$0.83	$1.14	16,673,654	16,673,654
Shorty Creek	90%	$0.18	$0.23	84,847,903	101,521,557
	50%	$0.33	$0.44	30,415,872	47,089,526
	10%	$0.67	$0.91	4,479,022	21,152,676
Globe Creek		$0.14	$0.17	91,980,000	193,501,557
Other Probable Prospects	90%	$0.14	$0.16	6,946,152	200,447,709
	50%	$0.13	$0.16	1,227,831	201,675,540
	10%	$0.13	$0.16	149,781	201,825,321
Tourism		$0.13	$0.16	0	201,825,321
Timber (TVSF)		$0.13	$0.15	25,852,960	227,678,281

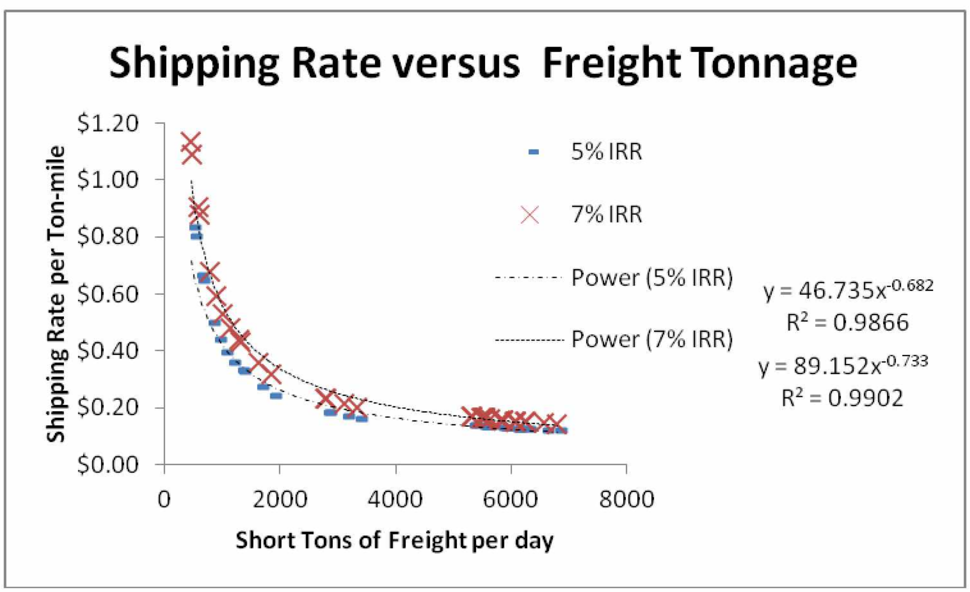

Figure 4.3 Shipping rate versus freight tonnage.

5.0 Livengood Money Knob Project Mine Model

5.1 Introduction to Money Knob Project Model

The ITH, Livengood Project, is the most developed exploration project in the Dunbar Livengood rail corridor and the first potential client for the rail services provided by the Dunbar-Livengood Extension. The mine model is based on linear regression of historical data and parameters procured from ITH press releases and other active mines. The parameters for the ITH perspective uses several scenarios based on different mine life, tonnage and resource estimates. The cost data are modeled using regression analysis equations. The purpose for the mine modeling is to demonstrate a shipping sensitivity analysis.

The initial research began using just the ITH published mine plan in the NI-43-101, and the Preliminary Economic Analysis. The ITH web news releases began to oscillate with mine plans, design, and nominal tonnage. To compensate for the changing data inputs, a group of models were developed based on the ITH base model, as an open pit mill and heap leach operation. The inputs of mine life, resource, tonnage and grade are used to assess the pit, mill, and heap costs with the 'Mine and Mill Equipment Costs an Estimator's Guide' (Leinart, 2009). The general result is four mine scenarios using different nominal tonnages and mine life. All four scenarios use the same base premise: an open pit truck-shovel operation, run of mine (ROM) valley fill heap leach, and a milling circuit.

The most recent project results, Table 5.1, are used in the independently prepared June 2010 in-situ mineral resource estimate for the Livengood gold project (Pontius, 2010b, g, h). The total resource estimates uses 420 diamond and reverse circulation drill holes, totaling 121,212 meters (Pontius, 2010g). The summer 2010 drill program completed 50,000 meters of drilling utilizing seven drills, four core and three reverse circulation (Pontius, 2010d).

Table 5.1 Mid-summer resource estimate for Money Knob Project

June 2010 Livengood Resources (at 0.7 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.7	201.7	1.07	6.9
Inferred	0.7	39.9	1.06	1.4
June 2010 Livengood Resources (at 0.5 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.5	408.6	0.83	10.9
Inferred	0.5	94.4	0.79	2.4
June 2010 Livengood Resources (at 0.3 g/t gold cutoff)				
Classification	Gold Cutoff (g/t)	Tonnes (millions)	Gold (g/t)	Million Ounces Gold
Indicated	0.3	788.9	0.62	15.7
Inferred	0.3	229.1	0.55	4

The most recent independent study for ITH uses a crushed material on the heap leach(Pontius, 2010i). The author chooses to stay with ROM on the heap leach, as in the previous ITH publications, because ROM is the input in the Walter Creek heap leach project at Fort Knox where some of the cost data was derived (Kerr, 2006).

The mine life is not easy to determine because the accuracy in predicting metal prices and re-supply costs diminishes significantly beyond twelve years. Ten to twelve years is the typical industry time frame for planning. This study uses mine life ranges from 16 to 36 years based on ITH press releases, resource volume and research. The actual mine life is expected to exceed thirty years.

The nominal mine tonnage ranges from 184,000 tons per day, the tonnage used in the Preliminary Economic Analysis (PEA) for ITH, to 410,000 tons per day, the production volume of the Goldstrike deposit (Barrick, 2000; Pontius, 2010f). The resource estimates ranges from 10.6 million ounces to 19.8 million ounces (Pontius, 2010b, f).

The mine model is designed to function year around using inputs of: 350 days per year, two 12 hour shifts per day, open pit, truck shovel, mill, heap leach, carbon in pulp recovery with a ore to waste stripping ratio of 1:1.07 (Pontius, 2010f). The initial input values use the published mean gold cutoff grade from the combined indicated and inferred resources from the ITH press releases (Pontius, 2010i, e, f). The combined indicated and inferred resource mean grade is determined from a weighted average of the indicated resource at a mean grade inferred resource.

The cited Money Knob Project PEA Resource estimates are 10.6 million ounces at 504,000 ounces per year with 78% average recovery, and a 0.3 ppm cutoff grade (Pontius, 2010f). The author found differing results for the cited resource, based on the published cutoff 0.3 ppm. When the author used the same published resource but a cutoff grade of 0.5 ppm, the author was able to reproduce the PEA resource of 10.6 million ounces. The 10.6 million ounces is reproduced by taking 78% recovery of the 13.3 million ounces at 0.0146 ounces per ton (0.5 ppm) cutoff in Table 4.2.

The base case, first scenario, for this study uses 184,086 tons per day, 10.6 million ounces combined indicated and inferred resource, with a cutoff grade of 0.024 ounces per ton (0.5 ppm), at an assumed fixed base gold price of $850 per troy ounce, and an effective recovery of 78 percent. The gold price sensitivity is analyzed from $800 to $1300 per ounce. The recovery is based on the ore being split approximately in half between the mill and the heap leach; where, the mill has 81 percent recovery and the heap leach has 73 percent recovery. The input parameters for mean grade and grade cutoff values were found in the September 13th, 2010 press release from the winter drilling program, see Table 4.2 and Table 4.3 (Pontius, 2010i).

The second, third and fourth scenarios split the ore tonnage with a mill grade cutoff of 0.02 troy ounces per ton (0.7 ppm) and a heap leach cutoff of 0.0088 troy ounces per ton (0.3 ppm) based on the cutoff grades from the published mine data (Pontius, 2009). Table 4.3 contains tonnage estimates for the mill and heap leach derived from Table 4.2. The mine life or the tonnage is fixed in second, third and fourth scenarios for comparisons.

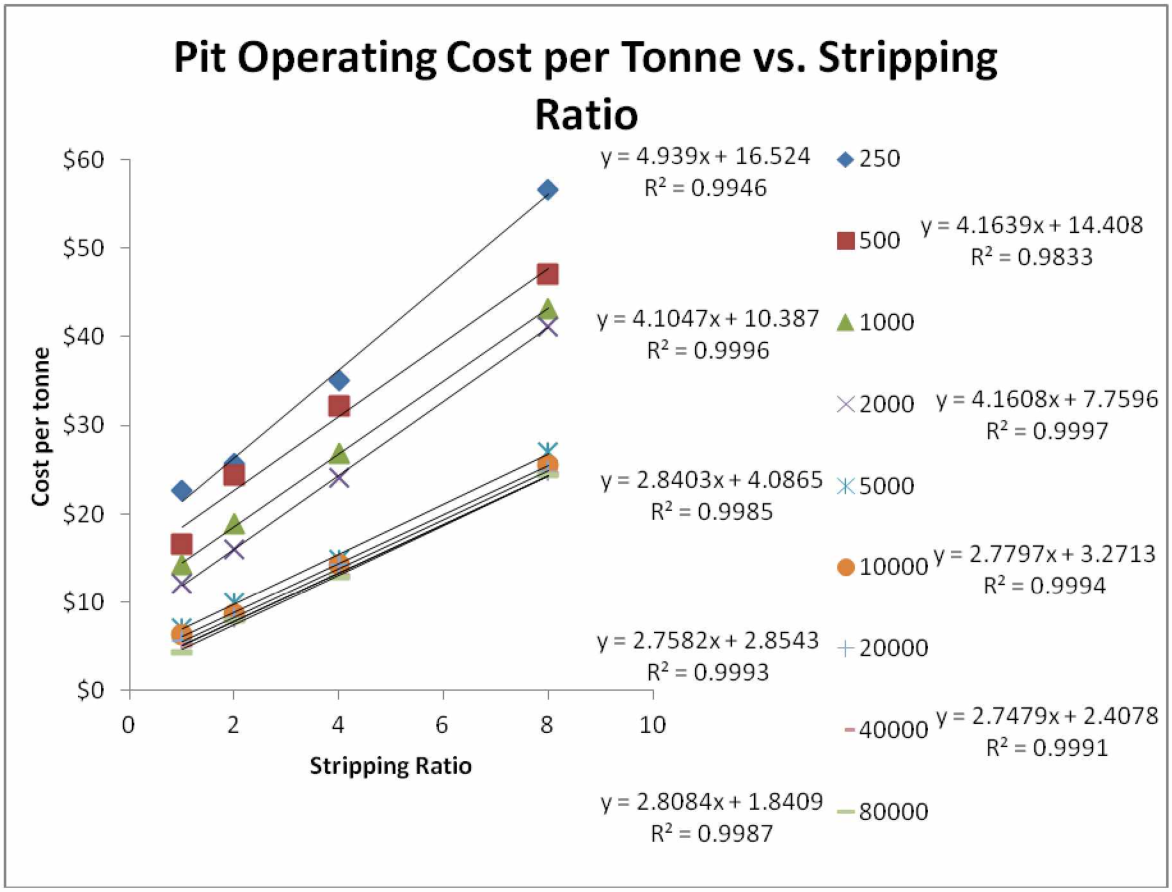

Figure 5.1 Pit operating cost per tonne versus the stripping ratio

5.2 Pit Costs

The operating and capital costs are developed with the Mine and Mill Cost Estimator's Guide (Leinart, 2009). The operating and capital cost per tonne data is plotted versus the ore tonnage and stripping ratio for each of the stripping ratios and tonnages respectively. Using regression analysis, equations are fit to model the cost data and to project the cost per ton for an input mining rate and stripping ratio. The following plots, Figure 5.1 through Figure 5.16, are for the 184,086 tons per day mine model. This model is used with each of the mine model scenarios.

The pit operating cost per tonne data is plotted versus the stripping ratio for each of the ore tonnages. Using regression analysis, equations are fit to model the operating cost data and to project the cost per ton for a mining rate at each of the stripping ratios, see Figure 5.1. Linear models best fit the data. For tonnages in the range of 5000 to 80,000 ore tonnes per day, the slope ranges from 2.7479 to 2.8403. The data trend indicates a negative vertical shift as the tonnage increases. The analysis returned R^2 values ranging from 0.9833 to 0.9997 indicating excellent correlation of the data to a linear trend.

The stripping ratio of 1.07 is input into each of linear regression equations, as X, (Figure 5.1) to estimate the pit operating cost at a stripping ratio of 1.07 for each specific tonnage: 250, 500, 1000, 2000, 5000, 10,000, 20,000, 40,000, and 80,000.

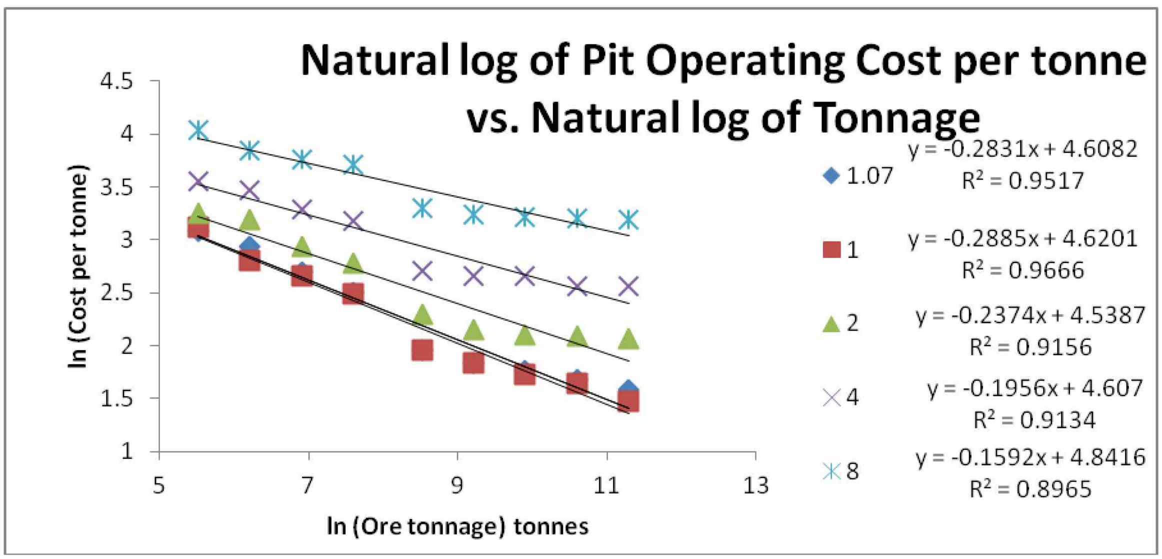

Figure 5.2 Log plot of the pit operating cost versus the log tonnage.

The comparison of the pit operating cost versus the tonnage data indicates a log-log relationship for the overall pit cost per ton data set (Figure 5.2). The natural log of pit operating cost per tonne data was plotted versus the natural log of ore tonnage for each of the following stripping ratios: one, two, four, and eight. Using regression analysis, equations are fit to model the pit operating cost data and to project the cost per tonne for the model input ore mining rate at each of the stripping ratios. Linear models fit the data well. The equation for the stripping ratio of one returned an R^2 value of 0.9666 indicating excellent representation of the data. The equation for the stripping ratio of 2 returned an R^2 value of 0.9156, indicating excellent representation of the data. The equation for the stripping ratio of 4 returned an R^2 value of 0.9134. The equation for the stripping ratio of 8 returned a good R^2 value of 0.8965. These fits visually appear to overestimate costs at lower tonnages and under estimate costs at higher tonnages producing a more conservative estimate for the operating cost values.

The ore tonnage from the mine input parameters is input as X in to each of the equations for each stripping ratio to produce an operating cost per tonne (Figure 5.2). The cost values data for the 1.07 stripping ratio is produced in the previous step. The stripping ratio of 1.07 is the mining plan value and this calculated value is plotted for a comparative check.

The log-log scale pit operating cost per tonne versus the tonnage data plot demonstrates two separate linear features, where the data greater than 5000 tonnes per day has a different trend from the data less than 5000 tonnes per day as if the two data sets are stepped apart showing efficiencies of scale. The data sets of interest are those representing the larger tonnage and they are plotted in Figure 5.3.

The pit operating cost per tonne data is plotted versus the ore tonnage for each of the following stripping ratios: one, two, four, and eight. Using regression analysis, equations are fit to model the operating cost data and to project the cost per ton for a mining rate at each of the stripping ratios, see Figure 5.3. Linear models best fit the data. The equation for the stripping ratio of one returned an R^2 value of 0.8539 indicating good representation of the data. The equation for the stripping ratio of 2 returned an R^2 value of 0.4765. The equation for the stripping ratio of 4 returned an R^2 value of 0.7971, indicating good representation of the data. This fit appears to under estimate lower tonnages and higher tonnages producing a more conservative estimate for the operating cost values. The equation for the stripping ratio of 8 returned a good R^2 value of 0.5602.

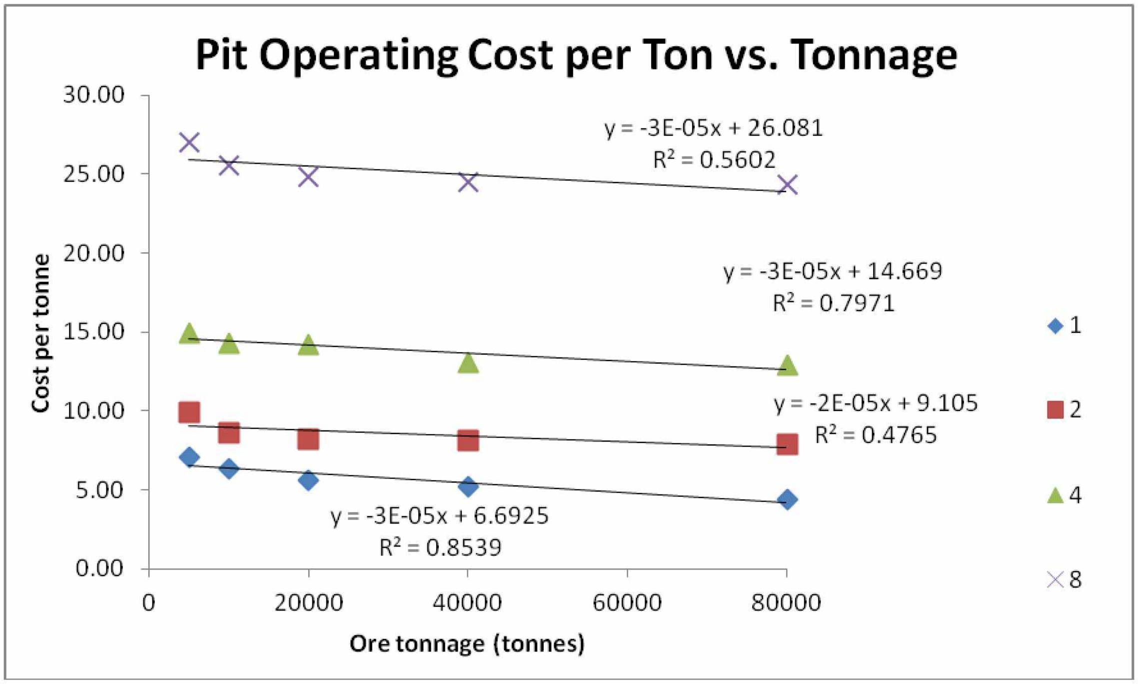

Figure 5.3 Pit Operating costs versus ore tonnage for 5000 to 80,000 tonnes per day

The estimated pit operating cost data was plotted versus the stripping ratio at specific mine tonnage per day (Figure 5.4). An equation was fit to the data to estimate the pit operating cost, at a given stripping ratio. The fixed tonnage is used to find the cost at the specific input stripping ratio with the understanding that the pit operating cost is the dependant variable and the stripping ratio is the independent variable in this analysis. The R^2 value 0.9995 indicates an excellent fit for the equation.

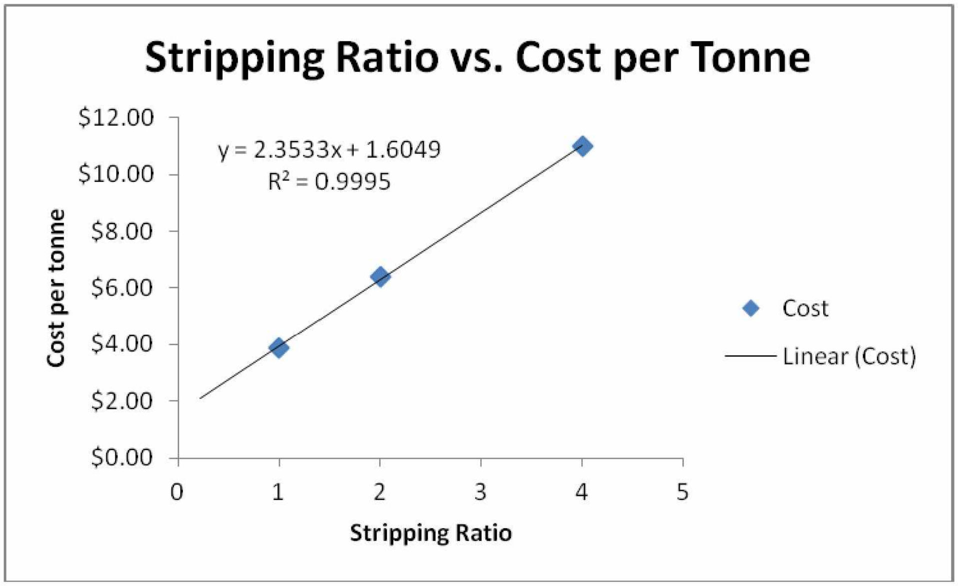

Figure 5.4 Cost per Tonne versus Stripping ratio at a fixed tonnage

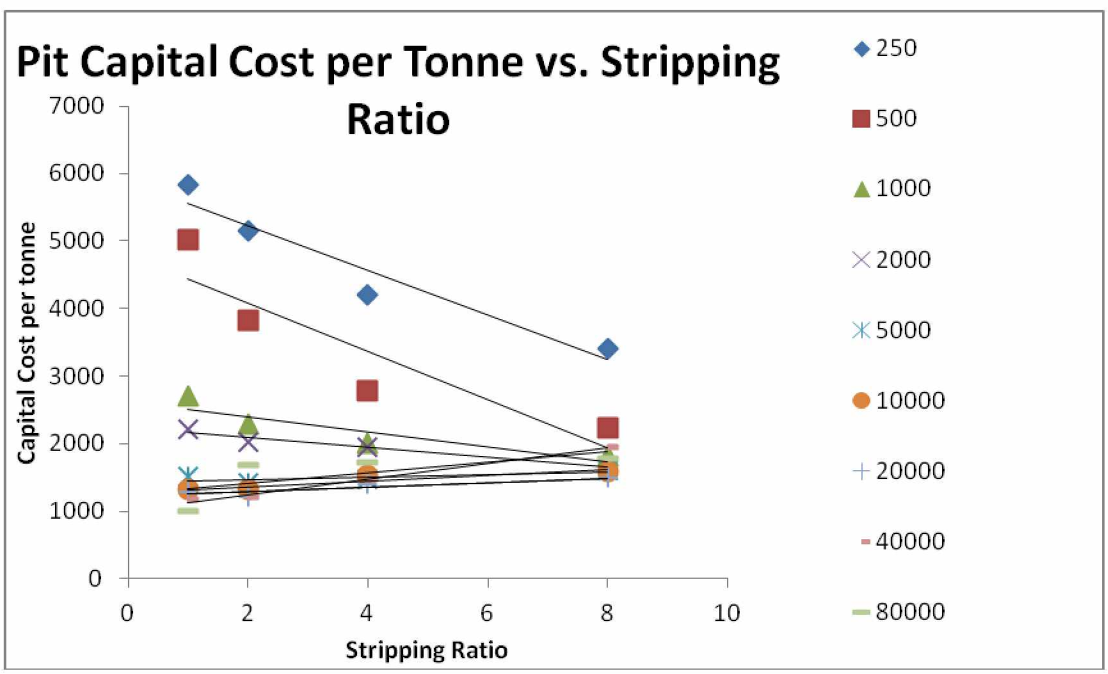

Figure 5.5 Plot of the pit capital cost versus the stripping ratio

The pit capital costs are estimated by plotting the pit capital costs versus stripping ratio data. The data is plotted for 250, 500, 1000, 2000, 5000, 10,000, 20,000, 40,000, and 80,000 ore tonnes per day (Figure 5.5). Using regression analysis, equations are fit to model the cost data and project the cost per ton for each of the mining rates (Figure 5.5). Linear models fit the capital cost versus stripping ratio data well. The stripping ratio is entered into the model to estimate costs for each of the mining rates.

The pit capital cost per tonne data was plotted versus the tonnage and the estimated cost values from input stripping ratio, 1.07. Using regression analysis, equations are fit to model the cost data and to project the cost per ton for each of the stripping ratios (Figure 5.6). Log normal models best fit the cost data. The analysis returned R^2 values ranging from 0.3364 to 0.9941 indicating poor to excellent correlation of the data to a linear trend. The better correlation values occur at the lower stripping ratios where our study occurs.

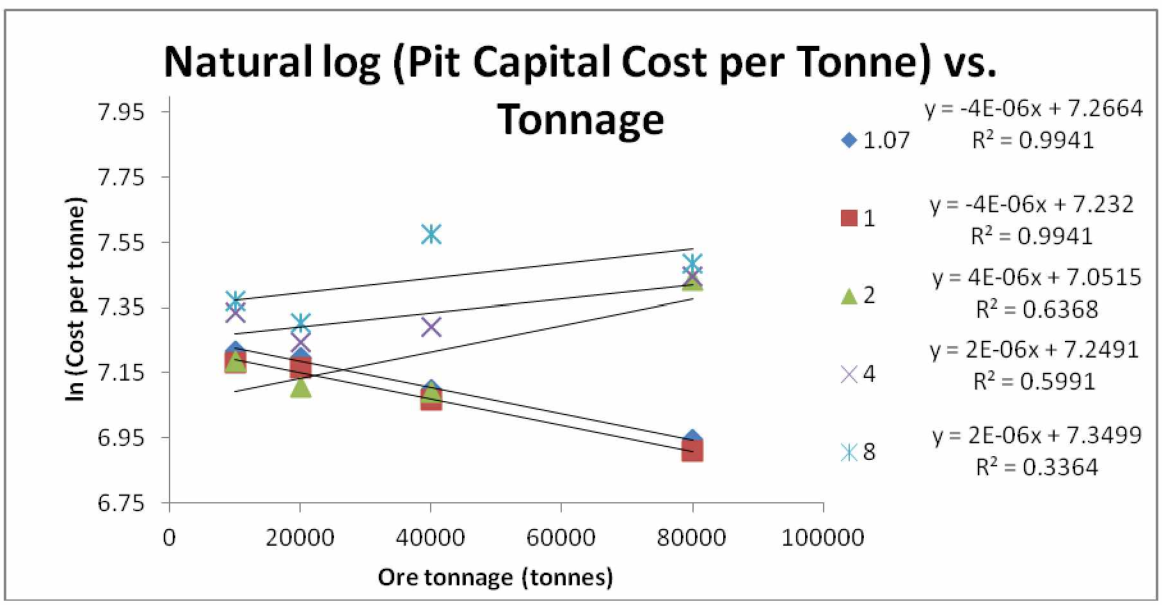

Figure 5.6 Log plot of the capital cost per tonne versus ore tonnage

5.3 Heap Leach Costs

Approximately 60% of the project is variably oxidized indicating a heap leach project. The heap leach was the Company's initial mining plan in the early studies completed November 30, 2009 (Klipfel and others, 2009; Meyers, 2009). The heap leach operation cost estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the cost per tonne (Figure 5.7). The power equation model best fits the data. The analysis returned R^2 values of 0.9903 indicating an excellent correlation of the data to a power trend.

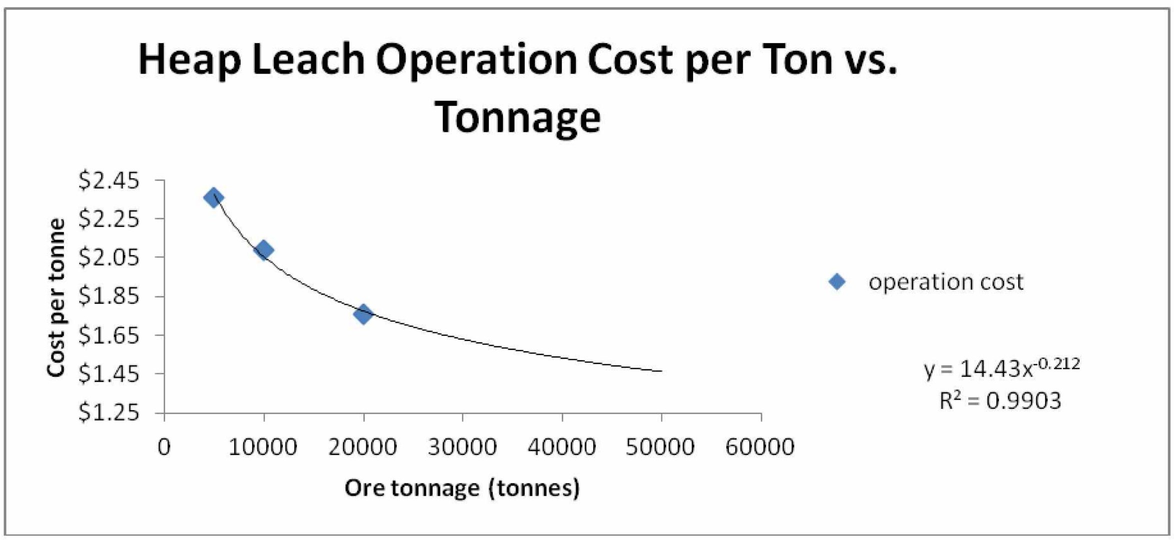

Figure 5.7 Plot of heap leach operation cost per tonne versus ore tonnage

The heap leach capital costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the cost per tonne (Figure 5.8). The power equation model best fits the data. The analysis returned R^2 values of 0.9996 indicating an excellent correlation of the data to a power trend.

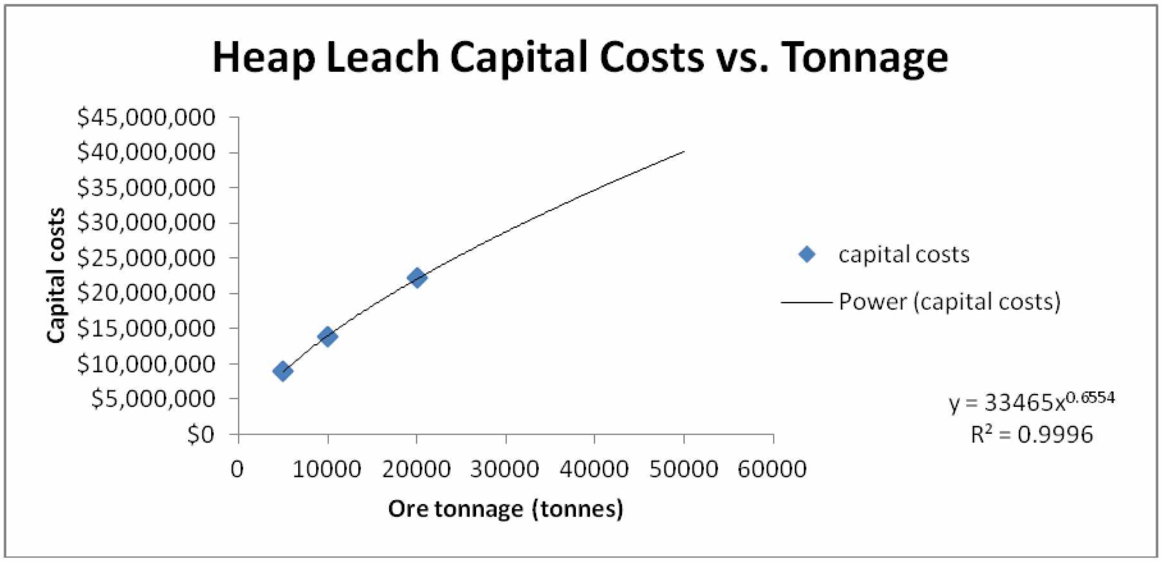

Figure 5.8 Heap Leach capital costs versus Ore tonnage

5.4 Mill (floatation) Costs

The ITH press releases indicate using a milling circuit to improve gold recovery. The model uses a floatation mill. Initial test work indicates significantly higher recoveries from milling from all ore types by utilizing a gravity circuit followed by carbon recovery processing of the tailing (Pontius, 2010a, i, f). The mill capital cost estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the capital cost data versus tonnage and to project the cost per tonne (Figure 5.9). The power equation model best fits the data. The analysis returned R^2 values of 0.9993 indicating an excellent correlation of the data to a power trend.

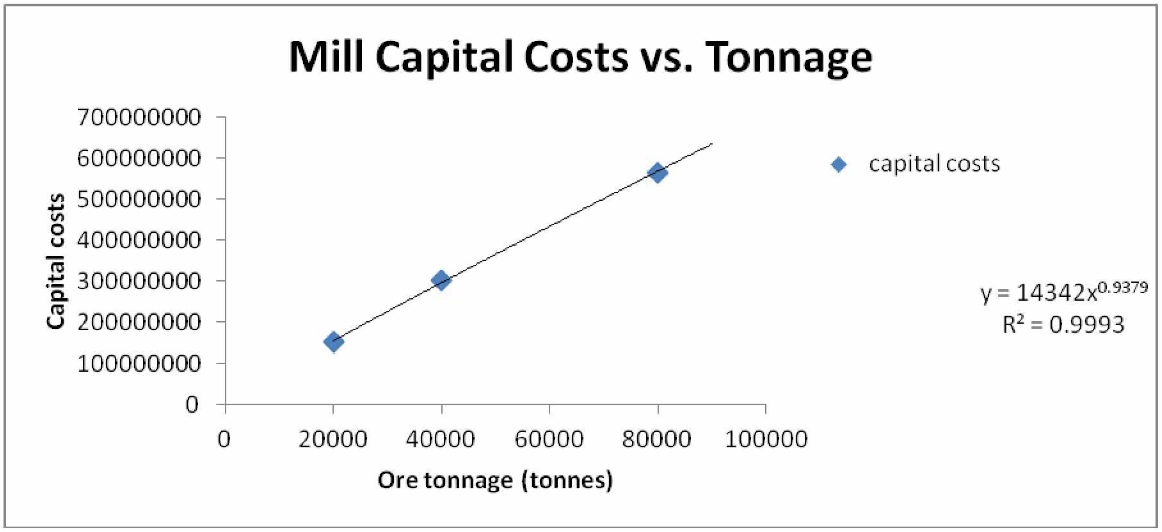

Figure 5.9 Mill capital costs versus ore tonnage

The mill operation costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the cost per tonne (Figure 5.10). The power equation model best fits the data. The analysis returned R^2 values of 0.9354 indicating an excellent correlation of the data to a power trend.

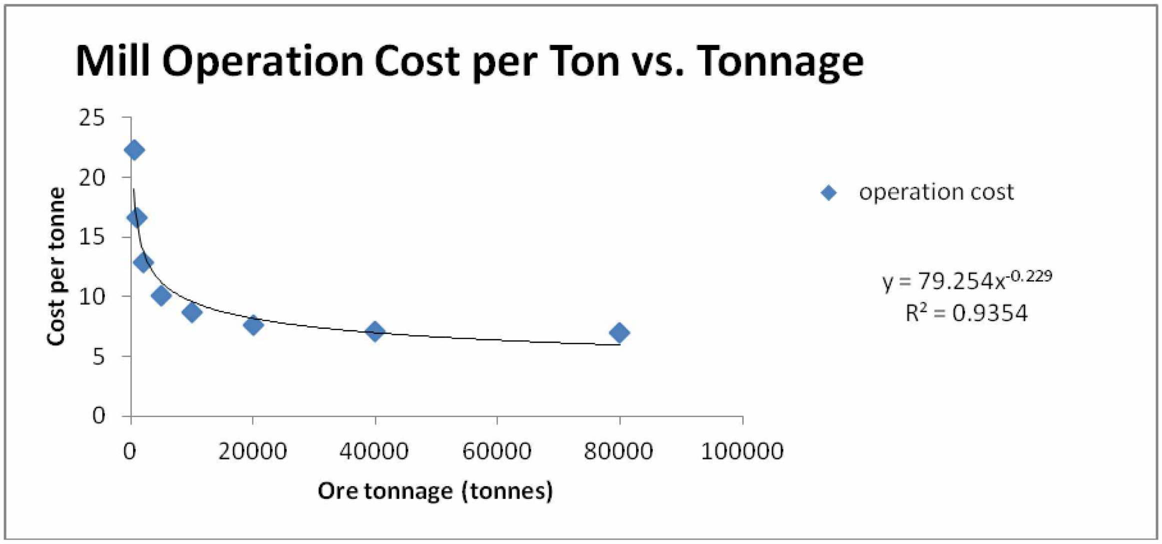

Figure 5.10 Mill operation costs per tonne versus ore tonnage

5.5 Gravity Recovery Circuit Cost

The free gold in the core indicates a gravity recovery circuit (Pontius, 2010i). The tonnage to the gravity recovery circuit is estimated at five percent of the mill throughput, separated by density classification, and the gravity concentrate waste is sent back into the cyanide circuit for further gold recovery. The gravity recovery operation cost estimates are plotted versus bulk cubic yards per day (bcy/d) in Figure 5.11, using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the cost per tonne (Figure 5.11). The power equation model best fits the process water pump and plant operator data. The analysis returned R^2 values of 0.9948 and 0.8555, respectively, indicating an excellent data correlation to a power trend.

The concentrating table returned a good correlation of 0.6691. The concentration table data steps from $0.03 per bcy, at 100 bcy/d, to $0.01 per bcy, at 250 bcy/d (Leinart, 2009). The operation cost data continues at $0.01 per bcy for concentration table feed input volumes of 250, 500, and 1000 bcy/d (Leinart, 2009). The data values may have been rounded or truncated; thus, lacking the level of precision to return better correlation values.

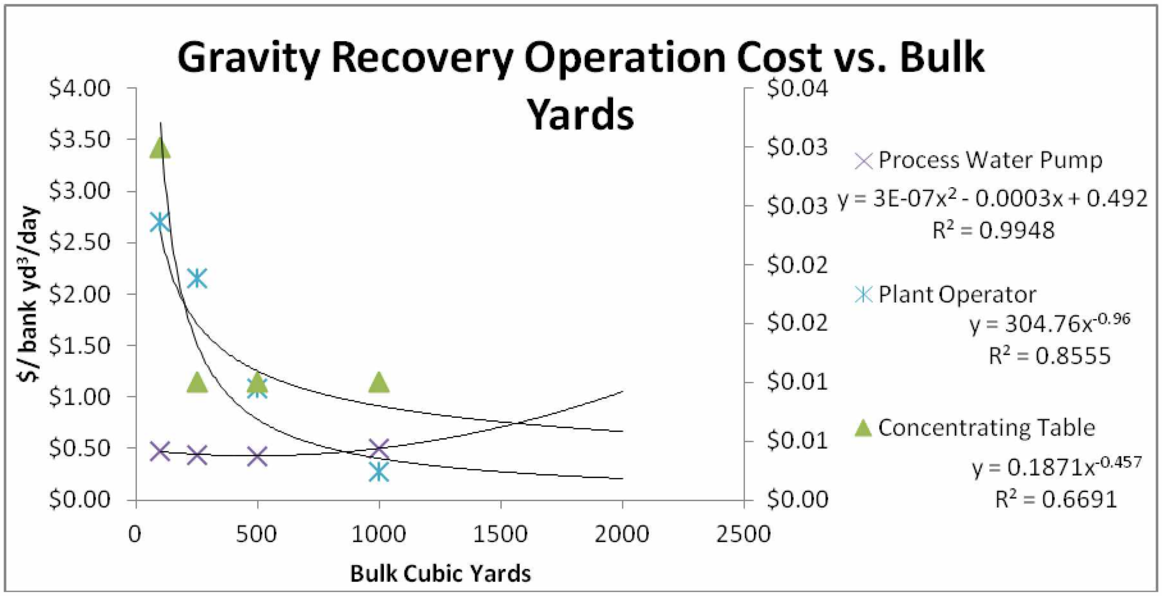

Figure 5.11 Gravity recovery operation costs versus bulk cubic yards

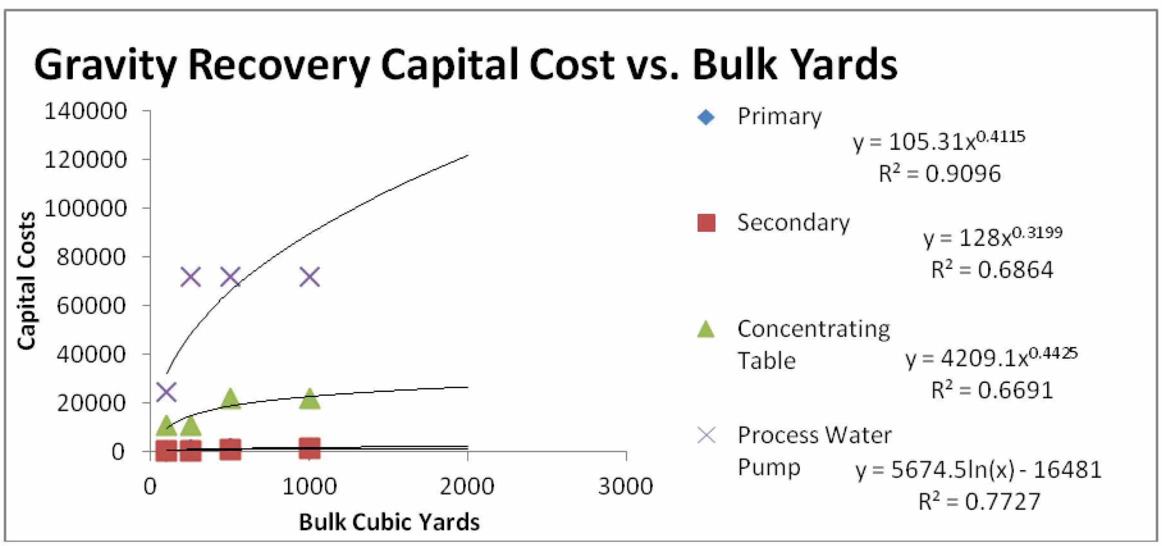

Figure 5.12 Data plot of the gravity recovery capital costs versus the bulk cubic yards

The gravity recovery capital costs are plotted versus bulk yardage using the Mine Cost data in Figure 5.12 (Leinart, 2009) with the concentrating table on the secondary axis. Using regression analysis, equations are fit to model the capital cost data versus tonnage and to project the cost per yard. The power equation model best fits the data. The analysis returned R^2 values of 0.9096, 0.6864, 0.6691, and 0.7727 for the primary classifier, the secondary classifier, concentrating table, and the process water pump respectively, indicating an excellent correlation of the data to a power trend and the process pump data to a log normal trend.

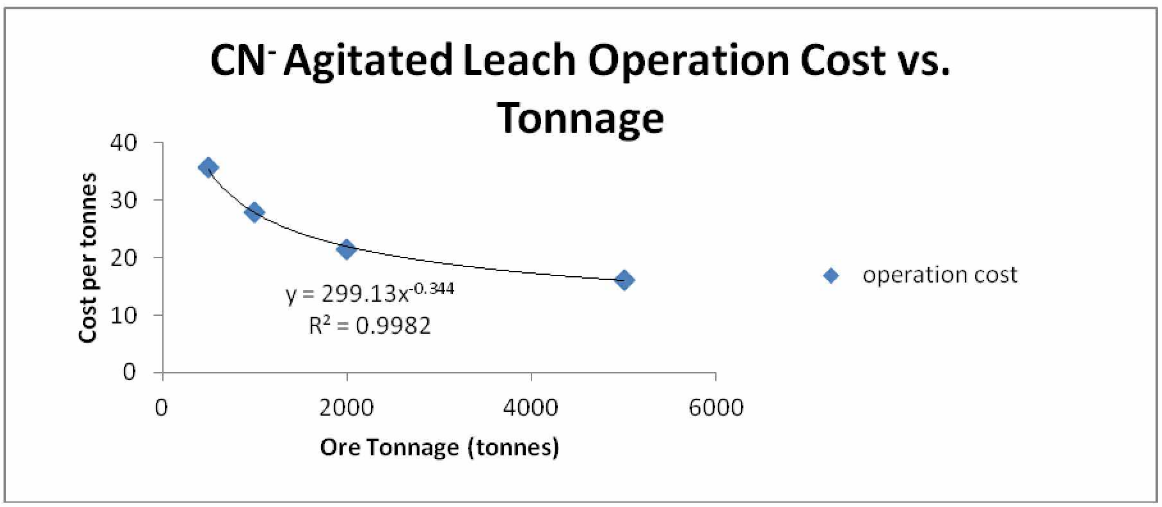

Figure 5.13 CN^- agitated leach operation costs versus ore tonnage

5.6 Cyanide Agitated Leach Costs

The cyanide agitated leach operating costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the operating costs per tonne, Figure 5.13. The power equation model best fits the data. The analysis returned R^2 values of 0.9982 indicating an excellent correlation of the data to a power trend.

The cyanide agitated leach capital costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the capital cost data versus tonnage and to project the cost per tonne, Figure 5.14. The power equation model best fits the data. The analysis returned R^2 values of 0.9993 indicating an excellent correlation of the data to a power trend.

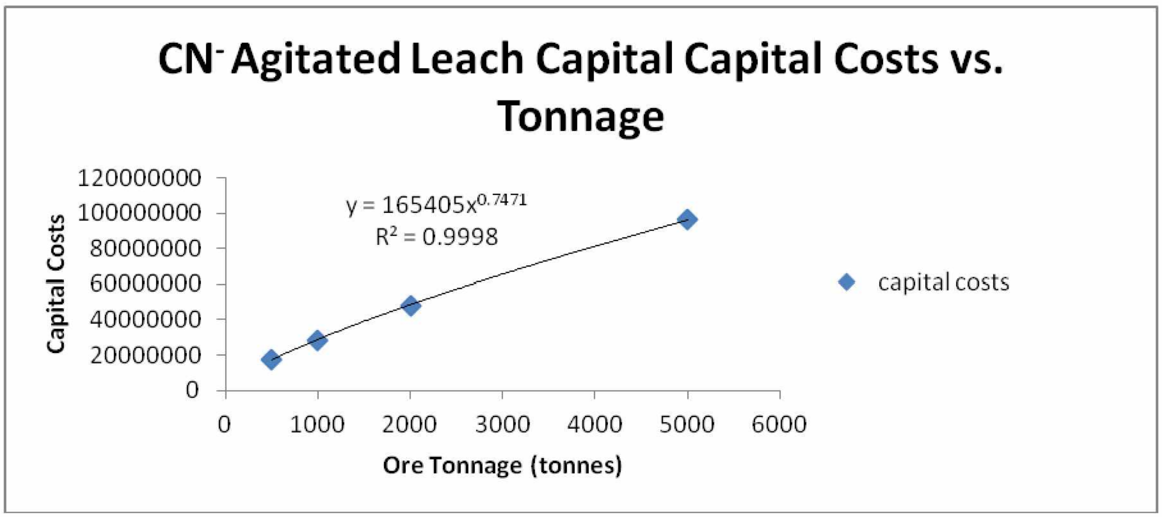

Figure 5.14 Plot of CN^- agitated leach capital costs versus ore tonnage

5.7 Carbon in Pulp Costs

The carbon in pulp (CIP) operating costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the operational cost data versus tonnage and to project the cost per tonne, Figure 5.15. The power equation model best fits the data. The analysis returned R^2 values of 0.91 indicating an excellent correlation of the data to a power trend.

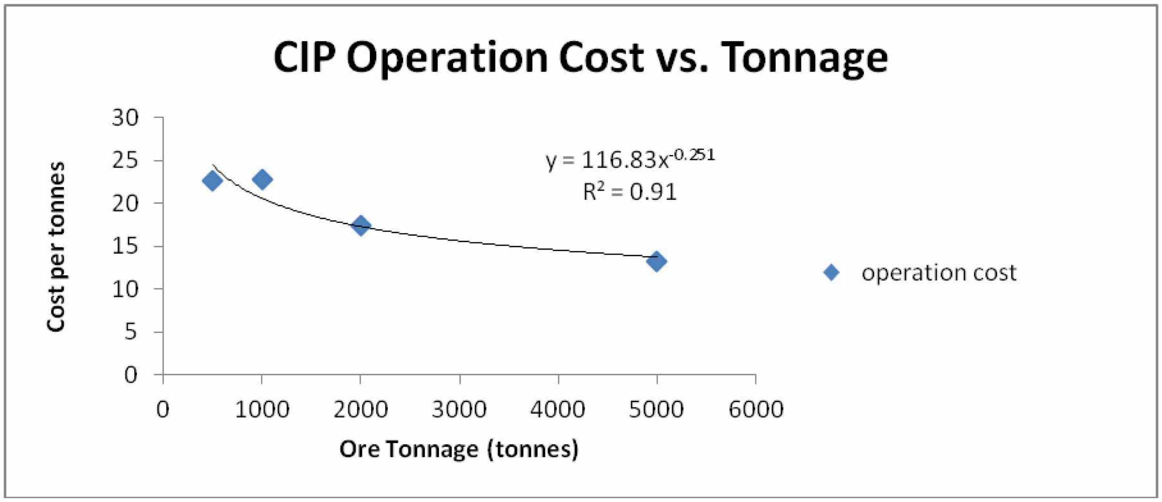

Figure 5.15 Carbon In Pulp operational costs plotted versus ore tonnage

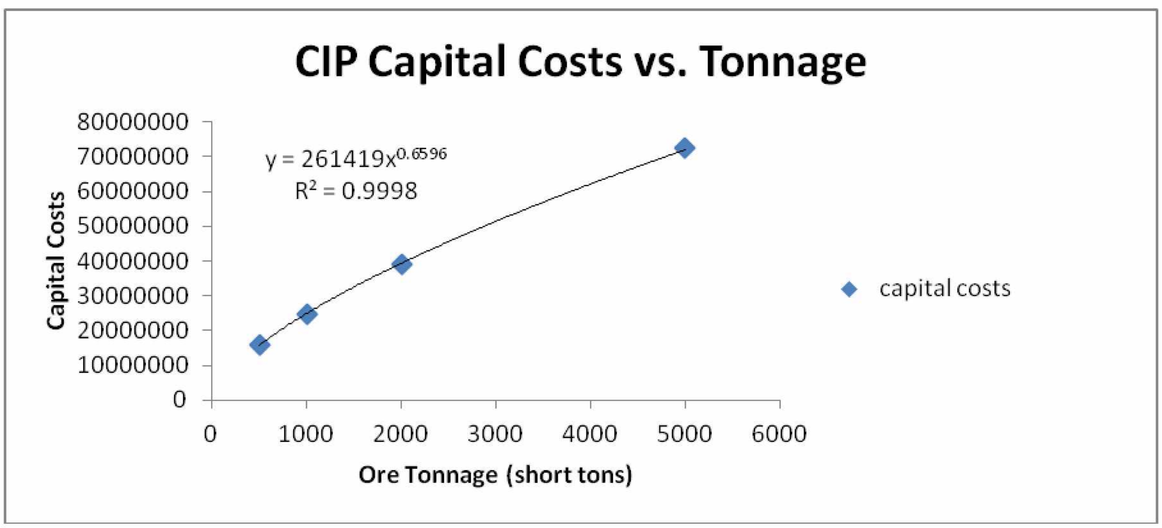

Figure 5.16. Carbon In Pulp capital cost data plotted versus ore tonnage.

The carbon in pulp (CIP) capital costs estimates are plotted versus tonnage using the Mine Cost data (Leinart, 2009). Using regression analysis, equations are fit to model the capital cost data versus tonnage and to project the cost per tonne, Figure 5.16. The power equation model best fits the data. The analysis returned R^2 values of 0.9998 indicating an excellent correlation of the data to a power trend.

5.8 Electric Power

E. Thorum, unpublished data, conducted research to model the electrical power analysis, trolley assisted truck analysis, and a fuel sensitivity analysis. Electrical power system infrastructures are large capital investments and the infrastructure sets the capacity for the mining rate. A good mine design is based on good geologic mapping and resource delineation. The economic optimization and mine planning estimate the mining rate by which to size the electrical infrastructure. The resulting data is used in the discounted cash flow analysis This report is not focused on mine optimization but instead uses the PEA mine design optimization and results for model inputs (Pontius, 2010i).

5.9 Trolley Assisted Haul Summary

E. Thorum's unpublished research finds,

> "...a trolley assisted haul system has significant advantages beyond the productivity gains, speed increases or reduced fuel consumption. Even under the worst case conditions, payback periods are very attractive. The fleet operating cost savings ranges from a low of 8.9% in the worst case conditions to a high of 32% in the best case, depending on fuel price and cost of electricity. Carbon savings is considerable given the potential impact from tax legislation. This work also serves to illustrate and clarify the full effect of trolley assisted haulage systems on an entire fleet as it pertains to the overall cost of mining. While it is wonderful to demonstrate a 50% savings in fuel consumption on the ramp, longer wheel motor life, lower maintenance costs and higher production rates, it is far more impressive to be able to see that a large scale mine can reduce the overall operating costs by 12 to 15 percent or more in places with more expensive fuel and less expensive electricity than Alaska. More complex configurations involving multiple circuits for both the up ramp and retarding legs can increase savings by as much as an additional 2% when fuel costs are approaching $5.00 per gallon and electricity is generated on site. As a final

word, trolley assisted hauling is woefully underutilized and warrants strong consideration."

5.10 Mine Model Cash Flow Analysis

The cash flow analysis uses the estimated revenue and costs from the mine model to determine different IRRs and NPVs for four mine model scenarios. The mine model outputs are entered into the cash flow model. The analysis independently varies the revenue, the recovery, the use and nonuse of trolley assisted haul trucks, and the shipping method- rail or truck to conduct sensitivity analyzes. The mine model is assessed in four scenarios differentiated by tonnage and mine life. The time frame for the discounted cash flow analysis is four years longer than the mine life, two years of pre development and two years reclamation. Neither assumption is an accurate time perspective for project development or the reclamation process. The exploration and reclamation costs are subject to the specific project, the mining method, and many unknowns. This is an attempt to account for these costs with the limited amount of data. Removing the development or reclamation cost has significant effects, of 3 to 10 percent increase in IRR.

The revenue is based on a constant input gold price and a constant effective recovery from the mine model. The gold price sensitivity analysis uses a range of gold prices from $800 to $1300 per ounce. The effective recovery is a first order weighted average based on tonnage to the mill and heap leach operations and the respective recovery. The recovery sensitivity analysis uses recoveries from 60 to 90 percent while holding the gold price constant. The mine model recovery uses the estimated tonnage to the mill and heap leach and the historical recovery, noted in the Mine and Mill Equipment Costs an Estimator's Guide, (Leinart, 2009). The smelter fees, the royalties, and the land lease are estimated at two percent, five percent, and $2.50 per acre per year respectively.

A shipping sensitivity analysis is conducted using estimated shipping rates derived from the respective rail and truck freight models. The shipping rates range from $0.12 to $1.14 per ton-mile. The derived shipping rates are entered in the Cash flow model iteratively as an annual expense and the respective IRR is recorded. The analysis uses the fixed gold price at $1100 per ounce and both trolley assisted and non-trolley assisted mine models of the first scenario. Figure 5.17 is a plot showing the negative correlation between the shipping rate and the IRR of the mine cash flow model.

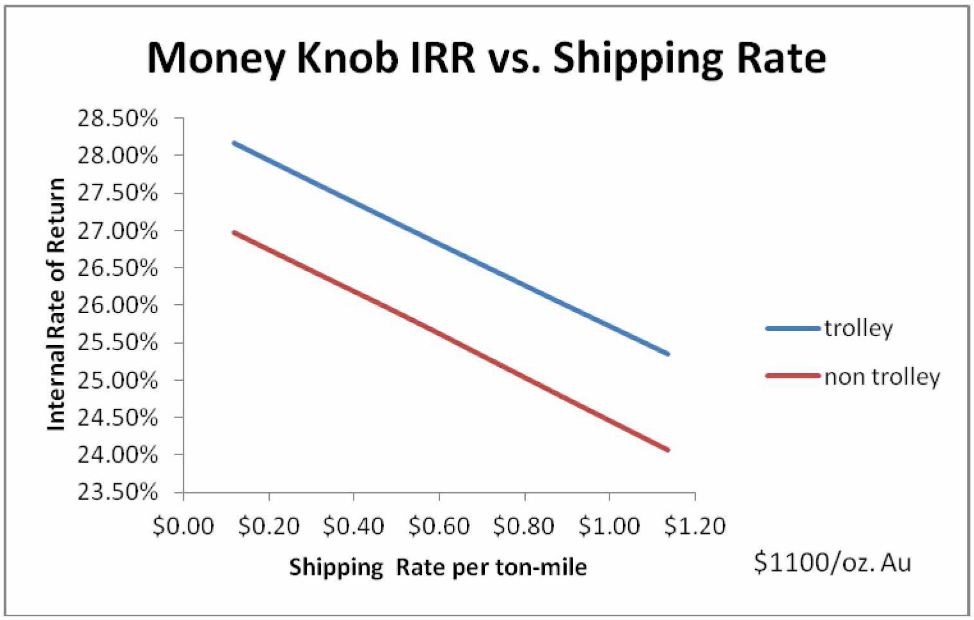

Figure 5.17 Shipping rate sensitivity analysis for the first scenario, trolley

The mine model cash flow is assessed in four scenarios differentiated by tonnage and mine life. Each individual model estimates operating and capital costs are summarized for the pit, the heap leach, the mill, and the trolley assisted haul trucks are contained in Table 5.2, Table 5.3, Table 5.4, and

Table 5.5, for the four different mine scenarios. The revenue row is broken down as the unit price (dollars per ounce), the revenue per day, the revenue per ton, and mean grade based on the effective recovery.

The costs are tabulated with the third column in each table as the capital costs and the fourth column as the operation cost per day. The trolley capital costs are shown in black and the operation costs are in red to reflect the modeled savings when using trolley assisted trucks. The summary tables do not reflect the discount time rate of capital, operation costs, and revenue. The results from the discounted cash flow analysis are displayed as the IRR versus Gold price for each of the four mine scenarios, Figure 5.18, Figure 5.19, Figure 5.20, and Figure 5.21.

Table 5.2 First mine model revenue, capital costs, and operating costs

		$/oz	$/day		$/ton	oz/ton	Recovery
Revenue		$850	$1,109,369		$12.47	0.0189	78%
Costs		Capital	Operation				
		US $	$/day	$/tonne	$/ton	Tones	Tons
Smelting	2%	of dore	$22,187				
Royalties	5%	smelter return	$54,359				
Land lease	$2.50	per acre	$74				
Pit		$83,415,964	$326,411	$1.95	$1.77	167000	184086
Heap		$34,917,837	$61,716	$1.53	$1.39	40338	44465
Mill		$299,318,903	$281,102	$6.97	$6.32	40338	44465
	gravity	$138,837	$1,634	$0.81	$0.73	2017	2223
	age CN-	$48,711,591	$44,128	$21.88	$19.85	2017	2223
	CIP	$39,559,746	$34,779	$17.24	$15.64	2017	2223
Trolley		$12,007,667	$29,351	$0.18	$0.16		
Cost totals		$518,070,544	$797,039	$4.77	$4.33		

The modeled mine cost compares well with the published values for similar mine costs: mining \$1.40 per tonne, milling \$6.24 per tonne, heap leach \$1.07 per tonne, and \$2.89 overall cost per tonne. The estimated mine costs from another gold mine of similar magnitude and location have published operating costs per ton of: \$1.10-\$1.44 mining costs, \$4.118 milling, \$0.98 heap leach operating, leach incremental capital \$0.20, G&A taxes etc. \$57.31 per oz for mill ore and \$20 per oz leach ore (Henderson and others, 2008). The ITH October 2009 Project Summary Report listed the following costs estimates per tonne: mining estimates \$1.80, G&A of \$0.6 and heap leach processing \$3.30 - \$4.22 (Klipfel and others, 2009). The mine cost estimates are subject to many assumptions, for example, some cost estimators do not include G&A in the mine per ton costs. The developed model includes the G&A at an estimated ten percent of the other costs. The shipping sensitivity analysis uses estimated shipping rates derived from the respective rail model and truck model.

Table 5.3 Second mine model revenue, capital costs, and operating cost

		$/oz	$/day		$/ton	oz/ton	Recovery
Revenue		$850	$909,981		$10.23	0.0176	68%
Costs		Capital	Operation				
		US $	$/day	$/tonne	$/ton	Tones	Ton
Smelting	2%	of dore	$18,200				
Royalties	5%	smelter return	$44,589				
Land lease	$2.50	per acre	$74				
Pit		$83,415,964	$326,411	$1.95	$1.77	167000	184086
Heap		$46,049,102	$86,093	$1.40	$1.27	61530	67825
Mill		$148,806,439	$158,283	$8.27	$7.50	19147	21106
	gravity	$102,864	$744	$0.78	$0.70	957	1055
	age CN-	$27,915,162	$27,060	$28.27	$25.64	957	1055
	CIP	$24,197,975	$19,910	$20.80	$18.87	957	1055
Trolley		$12,007,667	$29,376	$0.18	$0.16		
Cost totals		$342,495,172	$651,912	$3.90	$3.54		

Table 5.4 Third mine model revenue, capital costs, and operating costs

		$/oz	$/day		$/ton	oz/ton	Recovery
Revenue		$850	$1,562,236		$10.23	0.0176	68%
Costs		Capital	Operation				
		US $	$/day	$/tonne	$/ton	tonnes	Ton
Smelting	2%	of dore	$31,245				
Royalties	5%	smelter return	$76,550				
Land lease	$2.50	per acre	$74				
Pit		$113,429,131	$477,176	$1.66	$1.51	286702	316035
Heap		$65,621,478	$131,830	$1.25	$1.13	105633	116440
Mill		$247,031,228	$240,071	$7.30	$6.63	32871	36234
	gravity	$127,892	$1,205	$0.73	$0.67	1644	1812
	age CN-	$41,802,869	$38,580	$23.47	$21.30	1644	1812
	CIP	$34,562,634	$29,838	$18.15	$16.47	1644	1812
Trolley		$15,198,618	$50,612	$0.18	$0.16		
Cost totals		$517,773,850	$975,881	$3.40	$3.09		

Table 5.5 Fourth mine model revenue, capital costs, and operating costs

		$/oz	$/day		$/ton	oz/ton	Recovery
Revenue		$850	$2,026,728		$10.23	0.0176	68%
Costs		Capital	Operation				
		US $	$/day	$/tonne	$/ton	tonnes	Ton
Smelting	2%	of dore	$40,535				
Royalties	5%	smelter return	$99,310				
Land lease	$2.50	per acre	$74				
Pit		$124,645,882	$572,566	$1.54	$1.40	371946	410000
Heap		$77,827,822	$161,860	$1.18	$1.07	137040	151061
Mill		$315,337,987	$293,407	$6.88	$6.24	42644	47007
	gravity	$141,966	$1,800	$0.84	$0.77	2132	2350
	age CN-	$50,777,358	$45,767	$21.46	$19.47	2132	2350
	CIP	$41,037,299	$36,257	$17.00	$15.43	2132	2350
Trolley		$17,364,921	$65,731	$0.18	$0.16		
Cost totals		$627,133,235	$1,185,771	$3.19	$2.89		

5.11 Mine Modeling Results, at Specific tonnages

The IRR is strongly leveraged by gold price and the daily mine tonnage. This is shown as the IRR versus the market gold price in Figure 5.18, Figure 5.19, Figure 5.20, and Figure 5.21. The price of gold is a direct reflection of the mine revenue stream and a positive correlation between gold price and returns is expected. When comparing the mining cost data, it is found the unit cost decreases as the mining rate increases. This is reflected as the IRR is greater for larger mining rates. This could also be attributed to increase freight tonnage and decreases shipping rates.

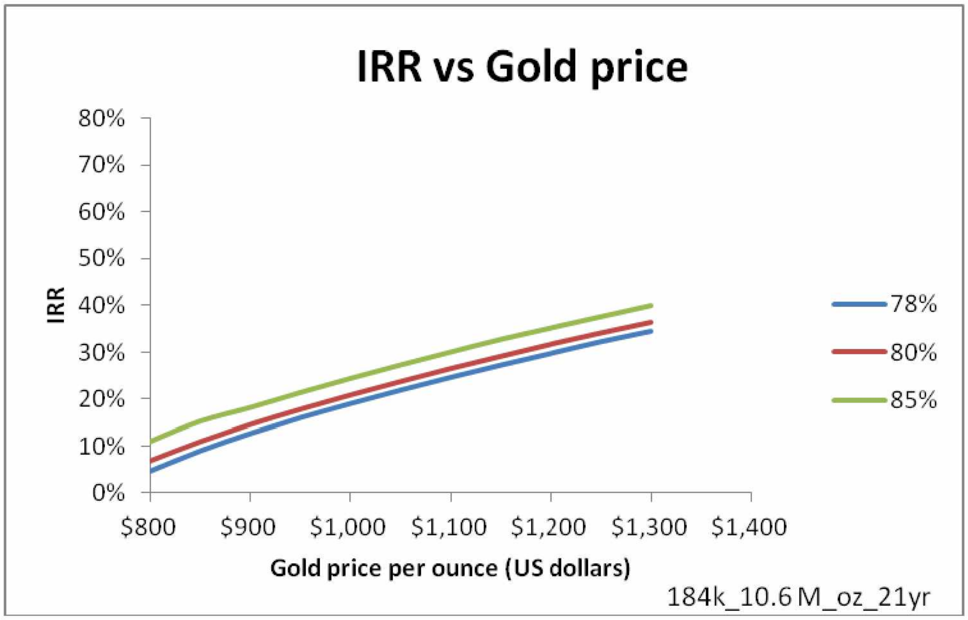

Figure 5.18 First mine scenario IRR versus Gold Price at different recovery rates

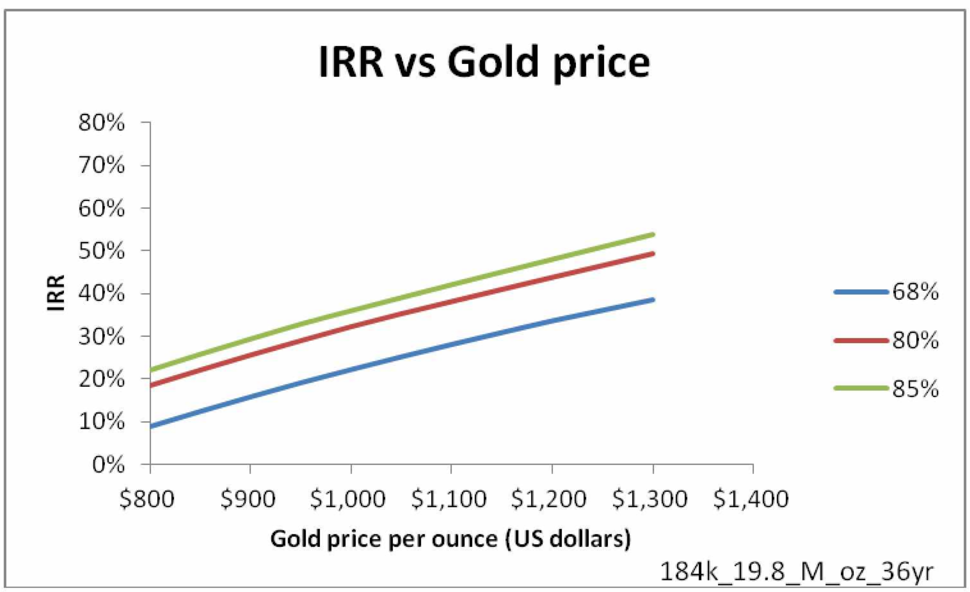

Figure 5.19 Second mine scenario IRR versus Gold Price at different recovery rates

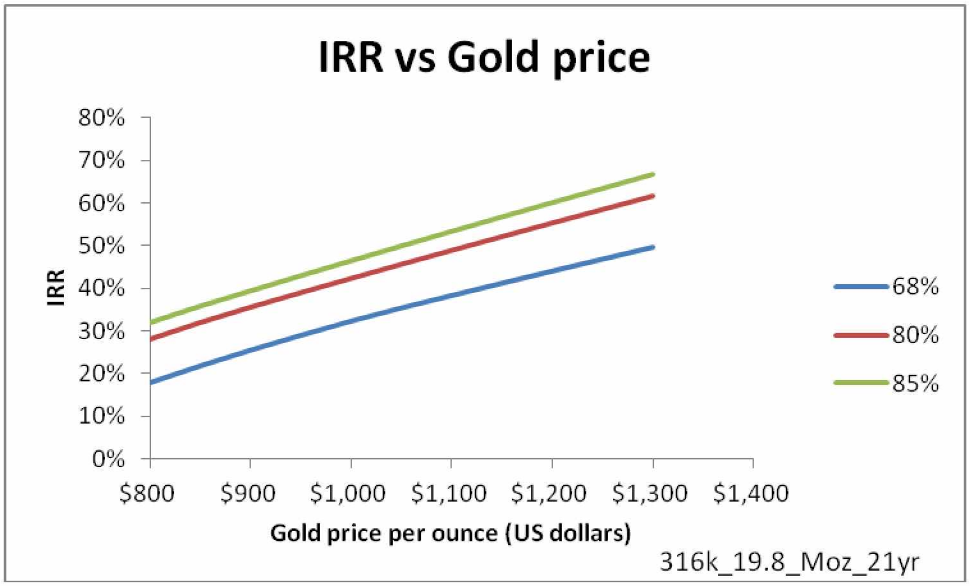

Figure 5.20. Third mine scenario IRR versus Gold Price at different recovery rates

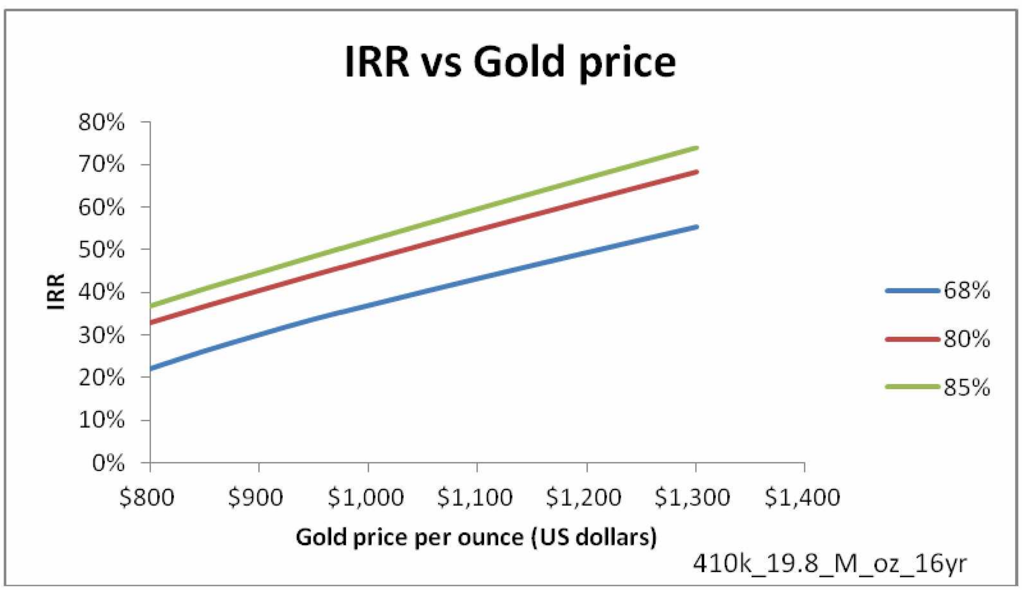

Figure 5.21 Fourth mine scenario IRR versus Gold Price at different recovery rates

Trolley assisted haul trucks have demonstrated significant savings over conventional haul trucks. The trolley assisted truck cost data is developed by E. Thorum's unpublished thesis research and is in late editing stages. The cost data is plugged into the discounted cash flow analysis. The IRR increases two percent with the modeled application of trolley assisted haul trucks (Figure 5.17). Where the IRR ranges between 9.5 and 13 percent for non-trolley mining operations, relative to the shipping rate, the two percent increase is 15 to 21 percent increase in profits from the application of trolley assisted haul trucks.

The returns on investment are related to the operation costs, lower shipping costs reduces operating costs. As the shipping costs decrease the IRR increases approximately 3.5 percent. The increases from lower shipping cost are as significant as the trolley assisted truck results in relation to the IRR. The larger mining rate, trolley assisted haulage, and the lower shipping rates indicate IRR increasing from 9 to15 percent or more.

6.0 Economic Benefits

The conservative resource estimates indicate a profitable freight potential for the ARRC and profits for Alaska's economy of greater than $2 billion annually in gross revenues. The mineral industry affects several levels of the state, national, and global economy(s): the mining, processing, finished manufactured goods, transportation, and others. Minerals are used every day in houses, offices, stores, cars, trucks, trains, electronics, cook wear, books, clothes, food, jewelry, food, construction materials, and to process other minerals.

> "The widespread effects of the struggling domestic economy were evident in the decreased performance of the U.S. minerals sector in 2009. Although minerals remained fundamental to the U.S. economy, contributing to the real gross domestic product (GDP) at several levels, including mining, processing, and manufacturing finished products, their contribution to the GDP was less than that in 2008. Trends in other sectors of the domestic economy were reflected in mineral production and consumption rates. For instance, continued declines in the U.S. housing market during 2009 were reflected in further reductions in the production and consumption of cement, clays, construction sand and gravel, crushed stone, and gypsum (commodities that are used almost exclusively in construction), and those associated with the related manufacture of goods, such as ceramic tile, paint, sanitary ware, roofing, and wallboard, used by the housing industry. Declines in automobile manufacturing resulted in reduced production and consumption of metals including, but not limited to, copper, iron and steel, lead, and platinum-group metals (U.S. Geological Survey, 2010)."

Non-Fuel minerals make up approximately 1/7th of the gross domestic product of $14,200 billion at $1,900 billion (U.S. Geological Survey, 2010). The conservative resources estimates within the corridor potentially compose 0.13 percent of the non-fuel mineral gross domestic product at less than 1 percent probability of development.

Alaska's mineral resource potential is under estimated and undervalued based on the limited geologic records. The geologic records for many mining camps are little to none and/or retained by prospectors who are reluctant to divulge the treasure hidden in their claims (Cobb, 1973). Where geologists and mining engineers have worked, the records are often the property of the "mine" and retained as proprietary records. Some of the existing records contain prospect location names and creek names that are unofficial, unrecorded, or do not exist on current maps. The incomplete data is of little value and it under estimates and overlooks potential mineral resources (Cobb, 1973).

Alaska's mining industry includes exploration, mine development, and mineral production of: zinc, lead, gold, silver, coal, as well as construction materials, such as sand, gravel and rock. The economic analysis of the adjacent White Mountains National Recreation Area and the Steese National Conservation Area is estimated at over $50 million, at mid1987 prices (White and others, 1989). It is currently under a mineral closure order by the Bureau of Land Management Resource Management Plan to reduce the expected quantity of gold produced by 112,000 ounces. The total economic value of the ARDF metal resource estimates are $392 billion at less than 1 percent known resource development.

The keys for resource development are location, market access, or transportation to markets. The resource must be transported to the market. The historic travel trade routes in Alaska are the rivers and ridge top trails traveled by canoes and dog teams and later by steam boats and cat trains. Current and historic communities have developed along these supply lines. The modern trade routes are the roads, the rivers, and the rail system. Rail is the most efficient overland transport method and second to downstream water transport. Low cost shipping is essential to develop the resources in Alaska. The investment in railroad infrastructure produces jobs not only for railroad employees but also for the retail and health care sectors (Ulmer, 2005).

Metal mines create an economic impact proportional to the gross metal values on surrounding communities and two jobs of direct support for each mining job (Rogers and Calvin, 1999). The rail extension will enhance the viability of several projects and resources: the Money Knob Gold Project, the Shorty Creek Project, the Globe Creek Limestone Project, the timber in the Tanana Valley State Forest, the Susitna Dam Project, and 417 other potential metal mineral prospects in the transportation corridor. This economic impact study estimates 1200+ direct jobs and 2400+ indirect jobs for the combined ARRC and ITH development.

The Mine model indicates approximately three percent greater IRR for the mine models using Trolley Assisted Trucks. The increased mining rate and decreased mine life indicates approximately nine percent greater IRR when the mine tonnage increases from 184,086 tons per day to 316,000 tons per day for the same 19.8 million ounce resource. The daily passenger shuttle service would eliminate the capital costs of a man camp, increase employee transportation safety, and add transportation service to rural communities by allowing miners to return home each day after work.

The conservative estimates of volume and tonnage for resources within the rail corridor are sufficient to recover the railroad capital costs and operating costs through the freight revenue. The true potential GMV within the corridor may be one to five percent the gross nonfuel mineral domestic product not the meager tenth of a percent (Table 6.1). This area only represents about one twentieth of the known metal prospects in the ARDF. The expansion of transportation networks creates the element of “location” and bringing Alaska’s resources to “markets” in the global community.

Table 6.1 Gross Natural Resource Value Estimates

	lower estimate	
Value per year		
$522,477,192	Money Knob	$850/oz Au, 21 year mine life
$1,148,305,289	Shorty Creek	50%tile Cu-Mo-Au Project 12 year mine life
$592,498,789	Metal Prospects	Average of the 10th, 50th and 90th GMV
$45,500,000	Globe Creek	Gross product value
$66,830,784	TVSF	$1290 per thousand board feet
$2,375,612,054		Gross Annual Product Value
	upper estimate	
Value per year		
$706,880,907	Money Knob	$1150/oz Au, 21 year mine life
$3,675,943,437	Shorty Creek	90%tile Cu-Mo-Au Project 30 year mine life
$1,777,496,368	Metal Prospects	10th, 50th and 90th GMV Sum, 12 year mine life
$45,500,000	Globe Creek	Gross product value
$66,830,784	TVSF	$1290 per thousand board feet
$6,272,651,497		Gross Annual Product Value

7.0 Cost Benefit Analysis

Engineering cost benefit analyzes are used to quantitatively study the effects a change will have on the environment, surroundings, private, public, safety, development, traffic, etc. This analysis uses the net present value of the benefits divided by the net present value of the costs to quantify the cost benefit ratio of the Dunbar-Livengood Rail extension. Cost benefit ratios greater than 1 indicate the benefits exceed the costs.

Railroads are long lived, large capital infrastructure projects with large benefit chains. Previous work compiled the estimated values for capital cost and operational cost for the proposed rail extension, the potential freight sources and tonnages, and the estimated freight rate for the alternative method of shipping the freight by truck. This cost benefit analysis takes place from two perspectives. The first perspective is of the Alaska Railroad Corporation (ARRC) where the benefits are the net freight revenue after the operating costs. The second perspective is from the public or end user where the major benefits are the savings from the lower freight rates and the difference between the cost of rail transport and a man camp operating costs.

The hurdle rate or minimum return on investment is argued to reflect the similar rates of return in large capital investments such as the Alaska Permanent Fund, 15 percent (in good years), or the OMB rate, 7 percent. The 30 year US Treasury Bond yield rate is 4.64 percent (Bloomberg, 2011) and the average inflation for 2010 is estimated at 1.64 percent (McMahon, 2011). The difference returns three percent as the effective minimum rate at zero growth. Five percent is greater than the minimum rate and it reflects the IRR for the ARRC determined from the financial report. It is noted that large public works projects may use lower hurdle rate, 5 percent or less. The hurdle rates of 10 and 15 percent reflect minimum returns in private investment ventures used to attract investors. This analysis uses 5 percent, 7 percent, 10 percent, and 15 percent as hurdle rates.

7.1 ARRC Perspective

The ARRC capital costs are the construction costs at approximately \$300 million. The capital costs are estimated from the “Rails to Resources to Ports”(Boland and others, 2007a), the “Yukon Short Track Report”(Boland and others, 2008), and the “Northern Rail Extension

EIS"(Rutson, 2009) at $5.5 million per mile for new rail construction and $1.3 million per mile for upgrades.

The ARRC operating costs are excluded from both the benefit and the cost of the rail road perspective analysis because the operating costs are included in the gross freight revenue rate and are also a direct function of the tonnage transported; where the operating cost is applied to each ton transported. Therefore, the cost perspective is the capital cost recovered through the benefits, net revenue streams, as a function of the freight tonnage transport. The costs are brought to net present value for an equivalent comparison with the net present value of benefits.

The direct benefit to the ARRC is the freight revenues. This benefit analysis for the ARRC uses the net present value for the positive net freight revenues above the operating costs. Several freight rates are used in this analysis to explore different scenarios as the actual freight rate is undetermined and this study returns a range of cost benefit ratios. The input net freight values are $0.12, $0.19, $0.26, $0.33, and $0.40 per ton-mile. For each freight rate the natural resource tonnages are added sequentially to analyze the benefit cost ratio for individual entities. The analysis also considers the summation of the group of freight producing entities. The major freight sources within the rail corridor are: Money Knob gold Project, Shorty Creek Project, Globe Creek Limestone Project, 417 prospects recorded in the Alaska Resource Data Files, Tanana Valley State Forest timber resources, and Tourism.

7.2 Public Perspective

Second is the public perspective. The analysis of the public benefits is vast and broad, covering the private entities of mining, forestry, freight transport, tourism, road maintenance, reduced road traffic, public safety, economic growth, etc. This public benefit analysis consists of the revenue savings from the reduced freight rate, and the savings generated from the commuter transport versus on site employee housing. The commuter rail transport generates externalities, which equates to more employee time at home, higher productivity from employees rested during travel, safer employee transport, and the expansion of public transport in interior Alaska between Minto and Manley, Nenana and Fairbanks. The focus of this study is not to define and discuss all the individual benefits but to focus on the major public benefits: reduced shipping costs, the cost of mine employee transport versus employee housing costs. The benefits will be brought to net present value for comparison with the net present value of costs.

The public perspective cost analysis includes the net present value of the capital costs and operating costs. The capital costs for construction of the rail link at approximately $300 million. The operating costs are estimated at $0.057 per ton-mile greater than the above mention net revenue rates of $0.12, $0.19, $0.26, $0.33, and $0.40 per ton-mile. For example, a net revenue rate of $0.12 per ton-mile for the ARRC equates to public freight rate of $0.18 per ton-mile. The estimated truck freight rate is approximately $0.55 per ton mile. The difference between the trucking transportation rate and the $0.18 per ton-mile rail rate is the estimated saving to the public entity is $0.37 per ton-mile. This is the construct of the comparative analysis between the ARRC benefit cost ratio and the public benefit cost ratio at a given freight rate.

The public perspective assesses individually the benefits for each of the natural resource, based on the cost savings of a lower shipping rate. This analysis generates a benefit cost ratio for each natural resource individually, sequentially, and cumulatively. Sequentially and cumulatively, the different resources have an assumed order of development and the benefits to cost ratio increases as more resources partake in the freight services increasing the tonnage transported. Stated differently, the benefits will increase until the Railroad reaches maximum capacity.

7.3 Cost Benefit Results

The results produce a range of benefit cost ratios with respect to the freight volume of entities using the rail service and the freight rate. The same net shipping rates used in the first perspective are used in the second perspective to compare the cost benefit analysis from the ARRC and public perspectives. The cost benefit results data is tabulated in Table 7.1 and displayed in Figure 7.1, Figure 7.2, Figure 7.3, Figure 7.4, Figure 7.5, and Figure 7.6. Not all the data (Table 7.1) is plotted but a portion for explanation of the results. The plotted results use the 7 percent discount factor referenced as the hurdle rate in the table and plots.

The cost benefit results data table is read as follows. The first column is the designation for the row data, name of the freight and passenger source. Benefit is the dollar value per ton-mile at a given freight rate to either the ARRC or the public. The first entry in the benefit row is $0.12 the net freight benefit to the ARRC the next entry is \$0.37 the shipping saving to the public. The next row “hurdle rate” is the discount rate applied to columns in groups of four separating the data horizontally, for example: columns 2 through 5 at 5 percent or columns 10 through 13 at 10 percent. Within the sections of three columns divided out by the discount rates the columns break down from left to right as: ARRC benefit cost ratio for just the single entity, the ARRC benefit cost ratio cumulatively added to the events above, the next column is the individual public benefit cost ratios, and the fourth column in the section is the cumulative public benefits.

Table 7.1. Cost Benefit Analysis Ratios

Benefit (freight rate)		$0.12	$0.37			$0.12	$0.37	
hurdle rate		5%				7%		
Benefit Cost ratio	ARRC		Public		ARRC		Public	
Money Knob	0.06	0.06	0.83	0.83	0.05	0.05	0.67	0.67
Shorty Creek	1.29	1.35	8.70	9.53	1.04	1.09	7.04	7.71
Shorty Creek	0.12	0.18	0.78	1.62	0.09	0.15	0.63	1.31
Shorty Creek	0.05	0.12	0.37	1.21	0.04	0.10	0.30	0.97
Globe Creek	1.31	2.66	7.74	17.24	1.05	2.15	6.26	13.95
PP	0.00	2.66	0.01	17.25	0.00	2.15	0.01	13.95
PP	0.00	2.66	0.03	17.28	0.00	2.15	0.03	13.98
PP	0.00	2.67	0.01	17.29	0.00	2.15	0.01	13.99
Timber	0.08	2.75	0.49	19.50	0.07	2.22	0.40	15.76
Tourism	0.01	2.81			0.00	2.27		
Benefit (freight rate)		$0.19	$0.30			$0.19	$0.30	
hurdle rate		5%				7%		
Benefit Cost ratio	ARRC		Public		ARRC		Public	
Money Knob	0.12	0.12	0.78	0.78	0.10	0.10	0.63	0.63
Shorty Creek	2.69	2.81	7.31	8.09	2.17	2.27	5.91	6.54
Shorty Creek	0.24	0.36	0.66	1.43	0.19	0.29	0.53	1.16
Shorty Creek	0.11	0.24	0.31	1.09	0.09	0.19	0.25	0.88
Globe Creek	2.77	5.58	6.29	14.36	2.23	4.50	5.09	11.61
PP	0.00	5.58	0.01	14.36	0.00	4.50	0.00	11.62
PP	0.01	5.59	0.03	14.39	0.01	4.51	0.02	11.64
PP	0.00	5.59	0.01	14.40	0.00	4.51	0.01	11.65
Timber	0.17	5.76	0.40	16.23	0.13	4.65	0.32	13.12
Tourism	0.01	5.82			0.00	4.70		

	$0.12	$0.37	
	10%		
ARRC		Public	
0.04	0.04	0.51	0.51
0.79	0.83	5.35	5.86
0.07	0.11	0.48	0.99
0.03	0.07	0.23	0.74
0.80	1.63	4.76	10.62
0.00	1.63	0.00	10.62
0.00	1.63	0.02	10.64
0.00	1.63	0.01	10.65
0.05	1.68	0.30	11.99
0.00	1.72		

	$0.19	$0.30	
	10%		
ARRC		Public	
0.08	0.08	0.48	0.48
1.65	1.72	4.50	4.97
0.15	0.22	0.40	0.88
0.07	0.15	0.19	0.67
1.70	3.42	3.88	8.84
0.00	3.42	0.00	8.85
0.01	3.43	0.02	8.86
0.00	3.43	0.01	8.87
0.10	3.53	0.25	9.98
0.00	3.57		

	$0.12	$0.37	
	15%		
ARRC		Public	
0.03	0.03	0.36	0.36
0.55	0.58	3.74	4.09
0.05	0.08	0.34	0.69
0.02	0.05	0.16	0.52
0.56	1.14	3.33	7.41
0.00	1.14	0.00	7.41
0.00	1.14	0.01	7.43
0.00	1.14	0.01	7.43
0.03	1.17	0.21	8.36
0.00	1.20		

	$0.19	$0.30	
	15%		
ARRC		Public	
0.05	0.05	0.33	0.33
1.15	1.20	3.14	3.47
0.10	0.16	0.28	0.61
0.05	0.10	0.13	0.47
1.18	2.38	2.70	6.17
0.00	2.38	0.00	6.17
0.00	2.39	0.01	6.19
0.00	2.39	0.00	6.19
0.07	2.46	0.17	6.96
0.00	2.49		

Table 7.1 continued

Benefit (freight rate)		$0.26	$0.23			$0.26	$0.23	
hurdle rate		5%				7%		
Benefit Cost ratio	ARRC		Public		ARRC		Public	
Money Knob	0.18	0.18	0.72	0.72	0.15	0.15	0.58	0.58
Shorty Creek	4.09	4.27	5.93	6.64	3.30	3.44	4.79	5.37
Shorty Creek	0.37	0.55	0.53	1.25	0.30	0.44	0.43	1.01
Shorty Creek	0.17	0.35	0.25	0.97	0.14	0.29	0.21	0.79
Globe Creek	4.23	8.49	4.85	11.47	3.41	6.86	3.92	9.28
PP	0.00	8.50	0.00	11.48	0.00	6.86	0.00	9.28
PP	0.01	8.51	0.02	11.50	0.01	6.87	0.02	9.30
PP	0.01	8.52	0.01	11.51	0.00	6.88	0.01	9.31
Timber	0.25	8.77	0.31	12.95	0.20	7.08	0.25	10.47
Tourism	0.01	8.83			0.00	7.13		

Benefit (freight rate)		$0.33	$0.16			$0.33	$0.16	
hurdle rate		5%				7%		
Benefit Cost ratio	ARRC		Public		ARRC		Public	
Money Knob	0.24	0.24	0.66	0.66	0.19	0.19	0.53	0.53
Shorty Creek	5.49	5.72	4.54	5.19	4.43	4.62	3.67	4.20
Shorty Creek	0.49	0.73	0.41	1.07	0.40	0.59	0.33	0.86
Shorty Creek	0.23	0.47	0.20	0.86	0.19	0.38	0.16	0.69
Globe Creek	5.69	11.41	3.40	8.59	4.59	9.21	2.75	6.95
PP	0.00	11.42	0.00	8.59	0.00	9.22	0.00	6.95
PP	0.02	11.44	0.02	8.61	0.02	9.23	0.01	6.96
PP	0.01	11.44	0.01	8.61	0.01	9.24	0.01	6.97
Timber	0.34	11.78	0.22	9.68	0.27	9.51	0.17	7.82
Tourism	0.01	11.84			0.00	9.56		

	$0.26	$0.23			$0.26	$0.23	
	10%				15%		
ARRC		Public		ARRC		Public	
0.11	0.11	0.44	0.44	0.08	0.08	0.31	0.31
2.51	2.62	3.65	4.09	1.75	1.82	2.54	2.85
0.22	0.33	0.33	0.77	0.16	0.23	0.23	0.54
0.11	0.22	0.16	0.60	0.07	0.15	0.11	0.42
2.59	5.21	2.99	7.07	1.81	3.63	2.08	4.93
0.00	5.21	0.00	7.07	0.00	3.63	0.00	4.93
0.01	5.22	0.01	7.08	0.01	3.64	0.01	4.94
0.00	5.22	0.01	7.09	0.00	3.64	0.00	4.95
0.15	5.38	0.19	7.96	0.11	3.75	0.13	5.55
0.00	5.42						

	$0.33	$0.16			$0.33	$0.16	
	10%				15%		
ARRC		Public		ARRC		Public	
0.15	0.15	0.41	0.41	0.10	0.10	0.28	0.28
3.36	3.51	2.79	3.20	2.34	2.44	1.95	2.23
0.30	0.45	0.25	0.66	0.21	0.31	0.17	0.46
0.14	0.29	0.12	0.53	0.10	0.20	0.08	0.37
3.49	7.00	2.10	5.29	2.43	4.87	1.46	3.69
0.00	7.00	0.00	5.29	0.00	4.88	0.00	3.69
0.01	7.01	0.01	5.30	0.01	4.88	0.01	3.70
0.00	7.02	0.00	5.30	0.00	4.89	0.00	3.70
0.21	7.22	0.13	5.95	0.14	5.03	0.09	4.15
0.00	7.26			0.00	5.06		

Table 7.1 continued

Benefit (freight rate)		$0.40	$0.09			$0.40	$0.09	
hurdle rate		5%				7%		
Benefit Cost ratio	ARRC		Public		ARRC		Public	
Money Knob	0.29	0.29	0.60	0.60	0.24	0.24	0.49	0.49
Shorty Creek	6.89	7.18	3.15	3.75	5.56	5.80	2.55	3.03
Shorty Creek	0.62	0.91	0.28	0.89	0.50	0.74	0.23	0.72
Shorty Creek	0.29	0.59	0.14	0.74	0.24	0.48	0.11	0.60
Globe Creek	7.15	14.33	1.96	5.70	5.77	11.57	1.59	4.61
PP	0.01	14.34	0.00	5.70	0.00	11.57	0.00	4.61
PP	0.02	14.36	0.01	5.71	0.02	11.59	0.01	4.62
PP	0.01	14.37	0.00	5.72	0.01	11.60	0.00	4.63
Timber	0.42	14.79	0.12	6.41	0.34	11.94	0.10	5.18
Tourism	0.01	14.85			0.00	11.99		

	$0.40	$0.09			$0.40	$0.09	
	10%				15%		
ARRC		Public		ARRC		Public	
0.18	0.18	0.37	0.37	0.13	0.13	0.26	0.26
4.22	4.40	1.94	2.31	2.94	3.07	1.35	1.61
0.38	0.56	0.17	0.54	0.26	0.39	0.12	0.38
0.18	0.36	0.08	0.45	0.13	0.25	0.06	0.32
4.38	8.79	1.21	3.51	3.05	6.12	0.84	2.45
0.00	8.79	0.00	3.51	0.00	6.12	0.00	2.45
0.02	8.81	0.01	3.52	0.01	6.13	0.00	2.46
0.01	8.81	0.00	3.52	0.00	6.14	0.00	2.46
0.26	9.07	0.08	3.94	0.18	6.32	0.05	2.75
0.00	9.11			0.00	6.34		

The Money Knob Project is the first entry and the first expected freight source. The ARRC and public cost benefit ratios for Money Knob Project do not indicate a profitable project from this sole perspective. The next entry is Shorty Creek. The Shorty Creek prospect is not three projects added sequentially but three different possible outcomes for Shorty Creek, each individually and combined with Money Knob Project as different possible combined outcomes. Only the 90th percentile modeled Shorty Creek Project is used in the continued summation of benefit cost ratios. All three of the Probable Prospects (PP) at the 90th, 50th, and the 10th percentiles are displayed individually added in sequentially into the cost benefit ratio because the conservative probability of occurrence applied in the above discussion indicates a portion of each level of prospect will be discovered and developed. The data tables are sectioned vertically into five groups by the different defined potential net freight revenue rates of \$0.12, \$0.19, \$0.26, \$0.33, and \$0.40 per ton-mile and the equivalent public benefit rate.

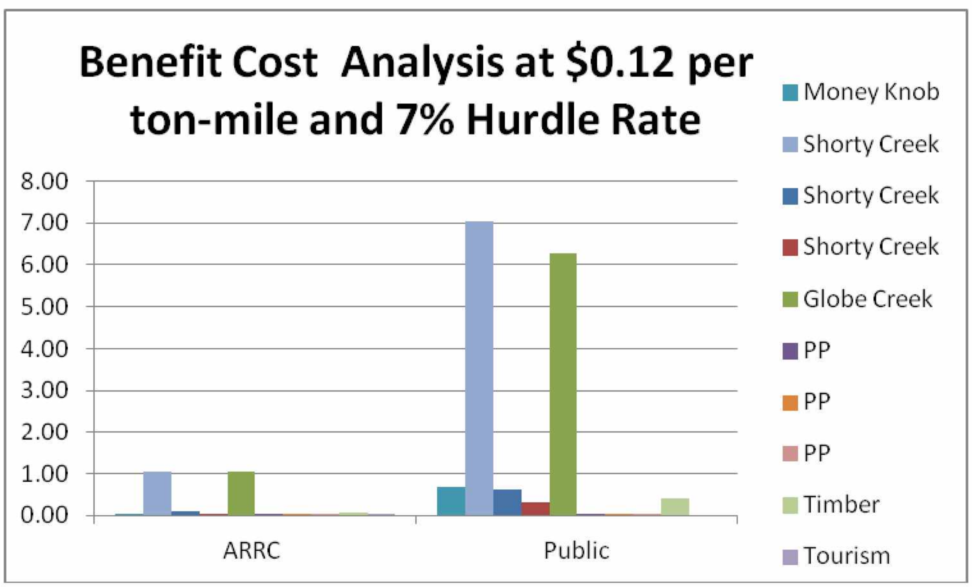

Figure 7.1 Individual Cost Benefit Ratio Bar Chart

The assessment of the individual freight/passenger sources is important because it defines which sources contribute most to the freight load and which public entities benefit more or less.

Figure 7.1, Figure 7.2, and Figure 7.3 plot the cost benefit results for an estimated net freight rate of \$0.12 for the ARRC and the gross freight rate of \$0.18 per ton-mile to the public, generating \$0.37 per ton-mile in freight savings. The purpose of Figure 7.1 is to separate each of the freight sources and show which sources provide positive benefit cost ratios individually. The freight and passenger benefits from the Shorty Creek Project and the Globe Creek Limestone Project individually show positive returns from the ARRC and the public perspectives. The low gross freight rate of \$0.18 per ton-mile indicates greater benefits for the public then the ARRC. The data series PP represents the other Probable Prospects at the 90th, 50th, and 10th percentiles has small tonnage estimates where the benefits are below the visible plotting.

Figure 7.2 is a plot of the individual cost benefit ratios for each freight sources as a bar chart and the cumulative combination as line graphs. The dip over the Shorty Creek prospects is because the cumulative value at that graph point is the sum of the singular Shorty Creek cost benefit value and the Money Knob Project cost benefit value. The freight and passenger benefits from the ninetieth percentile Shorty Creek Project and the Globe Creek Limestone Project are the major portions for positive cost benefit ratios for the ARRC and the public perspectives.

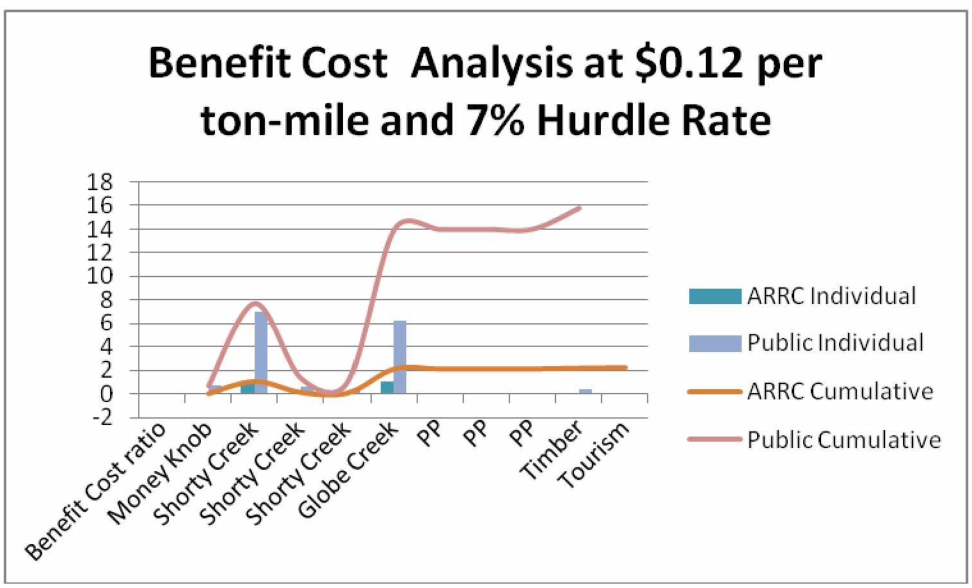

Figure 7.2 Cost Benefit Individual Bar Chart and Cumulative Line Graph

The cost benefit ratios are stacked in Figure 7.3 to show each of the freight source and the stacked combination of cost benefit ratios. Cost benefit ratios less than one reflect costs exceeding the benefits. The Shorty Creek prospect is represented only once as the 90th percentile deposit type. The two major contributors for a positive cost benefit result are Shorty Creek and the Globe Creek Projects.

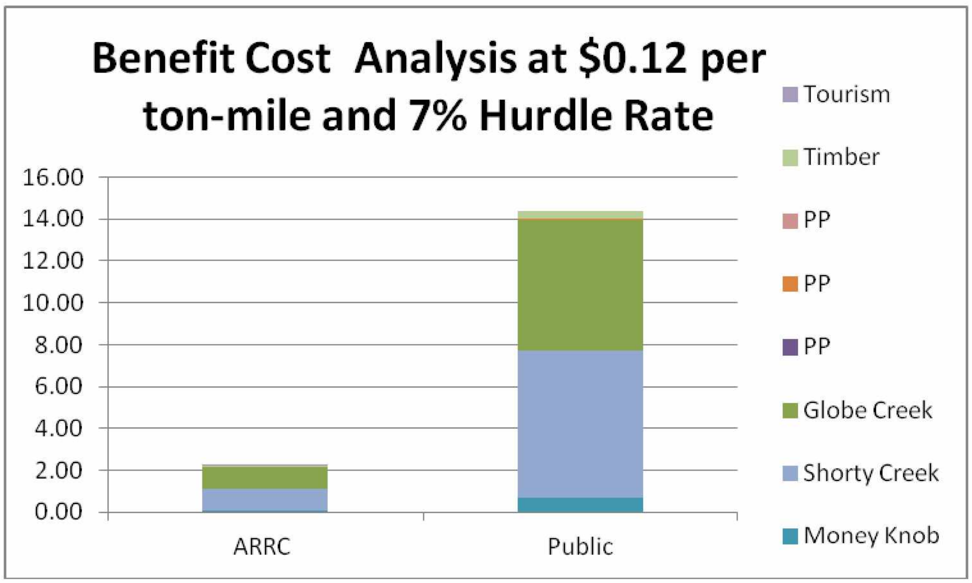

Figure 7.3 Cost Benefit Stacked Bar Graph

Figure 7.4, Figure 7.5, and Figure 7.6 plot the results for the net freight rate of $0.40 for the ARRC and the gross freight rate of $0.46 per ton-mile to the public generating $0.09 per ton-mile in freight savings. The bar graph in Figure 7.4 separates each of the freight sources as to which sources provide positive benefit cost ratios individually. The freight and passenger benefits from the Shorty Creek Project and the Globe Creek Limestone Project individually show positive returns from the ARRC and the public perspectives. The freight rate of $0.46 per ton-mile indicates greater benefit ratios for the ARRC perspective then the public perspective.

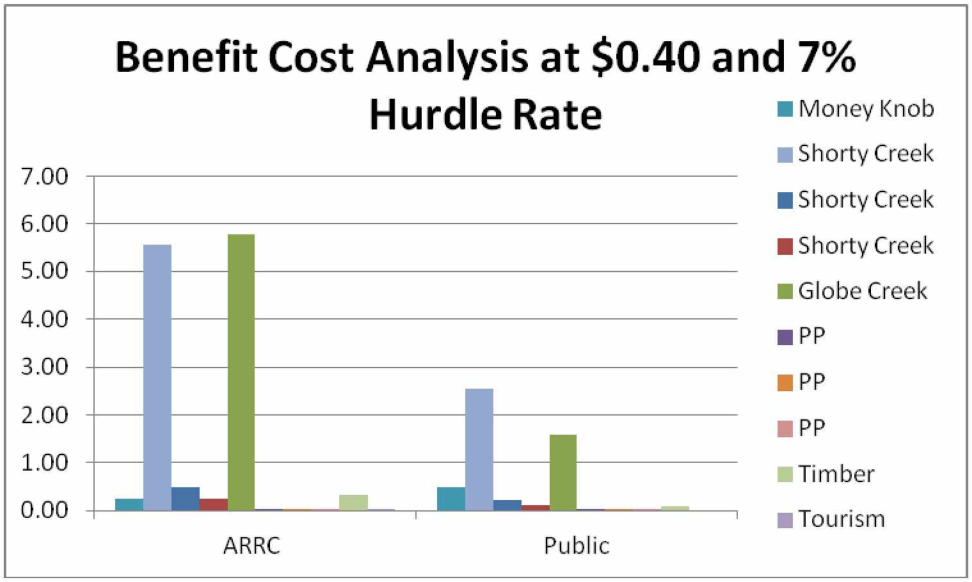

Figure 7.4 Bar Graph of Individual Benefit Cost Ratios

In Figure 7.5 each freight source cost benefit ratio is plotted individually as bar graph and cumulatively as line graphs. The dip over the Shorty Creek prospects is because the cumulative value at that graph point is the sum of the singular Shorty Creek cost benefit value and the Money Knob Project cost benefit value. The individual freight and passenger benefits from the Shorty Creek Project and the Globe Creek Limestone Project are the significant portions for positive cost benefit ratios for the ARRC and the public perspectives.

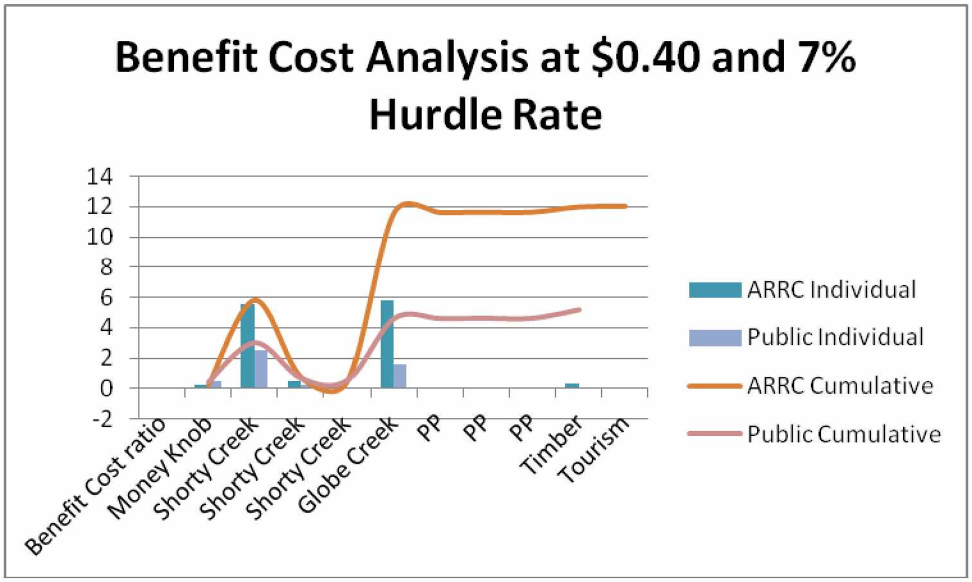

Figure 7.5. Individual Bar Plot with Cumulative Line Graph Benefit Cost Results

The stacked bar graph in Figure 7.6 delineates each of the freight sources and combines the sources as a stacked combination of cost benefit cost ratios. Cost benefit ratios less than one reflect costs exceeding the benefits. The Shorty Creek prospect is represented only once as the 90th percentile deposit type. The two major contributors for a positive cost benefit result are Shorty Creek and the Globe Creek Projects.

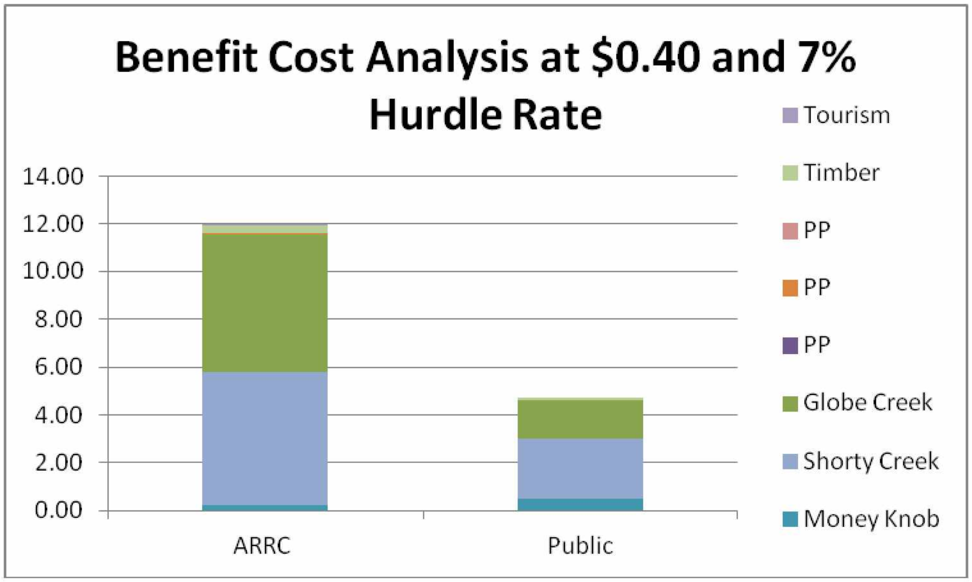

Figure 7.6 Individual Cost Benefit Stacked Bar Graph

The cost benefit analysis is directly linked to the freight rate and tonnage. The ARRC cost benefit ratio increases with freight tonnage and freight rate, as the revenue is directly proportional to freight tonnage. The public perspective benefit cost ratio increases as the freight rate decreases. The greater the hurdle rate, the lower the benefit cost ratio for the same freight tonnage for both perspectives as the preference is shifted to the present for the value of money.

8.0 Discussion

The cost benefit analysis indicates positive economic results for the total combined freight sources and the individual Globe Creek and Shorty Creek Projects' freight. When assessing the individual freight sources, most are lower tonnage and do not individually generate positive cost benefit ratios for the ARRC perspective. Specifically, the analysis for the 184,000 tons per day Money Knob Project model indicates benefit cost ratios of less than 1, negative returns, for both perspectives. However, the larger tonnage models (316k to 410k tons) for Money Knob Project do generate positive returns for both perspectives individually.

The analysis from the ARRC perspective is very straight forward in the form of a required freight rate necessary to recover capital and operating costs at a given tonnage; whereas the second perspective shipping sensitivity analysis for the end-users, (specifically Money Knob Project) is less direct. Money Knob Project benefits from the transportation service costs below subcontracted highway transport costs. These savings are the benefits. This shipping sensitivity analysis indicates that any rail freight rate below $0.55 per ton-mile generates proportional freight transportation savings. Employee rail shuttle transport saves approximately $138 Million in NPV in employee housing operation costs. Both increase the IRR for Money Knob Project.

The Elliott Highway is the major trucking route north. A preliminary estimate indicates twenty to thirty more trucks and five to eight more buses per day will be required just to serve the development at Money Knob Project. With the increased traffic and congestion, the accident rate could easily exceed the state historical accident statistics; thus, the traffic liability from only the traffic increase for the Money Knob Project is conservative. The rail transport and freight services could provide significantly safer alternative transport with far less liability than the Elliott Highway to Livengood.

The individual cost estimates are calculated using the annual mileage for Money Knob Project employees at 37 million passenger miles, $4 per gallon fuel, 20 miles per gallon fuel economy, and 200 miles round trip. The result is a unit cost of $0.40 per mile which could be as low as $0.10 per mile with carpooling which produces an upper annual cumulative value of $14.8 million for just Money Knob Project employees. These cost estimates are within the range of work conducted by others at 7 cents to 59 cents per mile (Delucchi, 1996, 1998; Raju, 2008; Gordon and Kolesar, 2010).

Considering the traffic fatality data, Alaska's fifteen year average is 1.8 fatalities per hundred million highway miles. This equates to a projected 0.67 deaths each year for the highway transport of employees to the Money Knob Project. (Noel, 2003; NHTSA, 2009, 2010b, a; Stickel, 2010d, a, c, b). The national regional rail average is 0.03 fatalities per 100 million miles, indicating 0.011 deaths per year if rail shuttle transport is used (LRN, 2003). If the deemed value of a life is $5.8 million, the NHSTA estimate, then the statistical annual highway death liability is $3.9 million and the statistical annual rail transport liability is $65,000 (Duvall and Gribbin, 2011). This only accounts for fatalities of the ITH employees traveling to and from work. Setting a dollar value on life provides a numerical value to compare highway and rail transport safety (sixty to one). This does not account for the time lost incidents: those without personal injury, minor injury, major injury, equipment damage, lost earnings, moose-vehicle accidents, etc. Hanson (1992) and Murphy and Delucchi (1998) cited the Wisconsin Department of Transportation data of average personal injury costs of $7,700 ($US 1982) and $1000 ($US 1982) in average lost earnings per accident. The moose-vehicle accidents account for over twenty percent rural highways accident incident (Thomas, 1995).

The benefits or costs to the individual citizen or from the perspective of the individual mine employee are significant if we assume employees drive themselves to work. The basic expense estimates incurred by the employee are composed of fuel, operation and maintenance, accident time loss, personal injury, death, non-injury time loss, etc.

9.0 Conclusions and Recommendations

9.1 Conclusions

The large resource base within the Dunbar-Livengood Corridor indicates an excellent freight potential with generous benefits for the Dunbar-Livengood Rail Extension's operators and patrons. The required rail freight rate necessary to recover capital and operating costs, and generate shipping rate benefits to the end-users is directly dependent on the tonnage or volume transported with an inverse relationship. As the freight tonnage increases, the freight rate decreases. The Shorty Creek or the Globe Creek occurrences create a positive cost benefit results when the freight tonnage estimates exceed 680 tons per day. With freight tonnage below this minimum volume, it is more economical to transport freight by truck. Thus natural resource development and railroad infrastructure development are synergistic with respect to the Dunbar-Livengood Rail Extension.

9.2 Recommendations

Future work on a railroad extension from Dunbar to Livengood should include the truck on rail, or the through traffic, private individual costs and benefits, and potential land use impacts.

10.0 References

1973, RST Casefile Summary, Dunbar-Brooks Terminal, State of Alaska Department of Natural Resources, v. AS 19.30.400(d).

Abacus, 1991, Rail vs. Truck Fuel Efficiency: The Relative Fuel Efficiency of Truck Competitive Rail Freight and Truck Operations Compares in a Range of Corridors: Abacus Technology Corporation FRA/RRP-91/2 [Report prepared for the Federal Railroad Administration].

Albanese, M.D., 1982a, Geochemical reconnaissance of the Fairbanks D-3 Quadrangle; summary of data on stream-sediment, pan-concentrate, and rock samples: Alaska Division of Geological & Geophysical Surveys Alaska Open-File Report 166, 17 p.

Albanese, M.D., 1982b, Geochemical reconnaissance of the northern Fairbanks D-1 and southern Livengood A-1 Quadrangles; summary of data on pan-concentrate, stream-sediment, and rock samples: Alaska Division of Geological & Geophysical Surveys Alaska Open-File Report 164, 28 p.

Albanese, M.D., 1982c, Geochemical reconnaissance of the northern Fairbanks D-2 and southern Livengood A-2 Quadrangles; summary of data on stream-sediment, pan-concentrate, and rock samples: Alaska Division of Geological & Geophysical Surveys Alaska Open-File Report 165, 25 p.

Allais, M., 1957, Method of Appraising Economic Prospects of Mining Exploration over Large Territories: Algerian Sahara Case Study: Management Science, v. 3, no. 4, p. 285-347.

ARRC, 2010a, Alaska Railroad Fact Sheet, Alaska Railroad Corporation, no. June 18, 2010, http://www.alaskarailroad.com/corporate/AboutARRC/FactSheet/tabid/452/Default.aspx.

ARRC, 2010b, Alaska Railroad History, v. 2010, no. June 22, 2010, http://www.alaskarailroad.com/corporate/AboutARRC/ARRCHistory/tabid/453/Default.aspx.

ARRC, 2010c, Mission Statement, Alaska Railroad Corporation, no. June 18, 2010, http://www.alaskarailroad.com/corporate/AboutARRC/FactSheet/tabid/452/Default.aspx.

Ashcroft, M., Vagenas, N., and Baiden, G., 1999, Maintenance and Cost Evaluation of an Automated Haulage Truck at INCO Limited: Mineral Resources Engineering, v. 8, no. 2, p. 181.

ASTM, 2004, Standard Test for One_Dimensional Consolidation Properties of Soil Using Incremental Load, *in* International, A., D2435-04, ASTM, p. 10.

Bailly, P.A., 1964, Methods, costs, land requirements and organization in regional exploration for base metals, AIME Meeting, Alaska Section: Fairbanks, Alaska, p. 55.

Barnes, D.F., 1961, Gravity low at Minto Flats, Alaska: U.S. Geological Survey Professional Paper U.S.G.S., no. Short papers in the Geologic and Hydrologic Sciences, p. D254-D257 U.S. Geological Survey

Barrick, 2000, First Quarter 2000 Report: Barrick Reports $72 Million in First Quarter Earnings, 14 p. [Press Release].

Battelle, 1995, Comprehensive Truck Size and Weight (TS&W) Study, Phase 1-Synthesis, Energy Conservation and Truck Size And Weight Regulations, 21 p.

Bear, J., 1972, Dynamics of Fluids in Porous Media, Dover.

Bloomberg, 2011, Markets-Bond Rates, Bloomberg.com, v. 2011, no. 03 March, http://www.bloomberg.com/markets/rates-bonds/government-bonds/us/.

Boadway, R., 2006, Principles of Cost-Benefit Analysis: Public Policy Review, v. 2, no. 1, p. 44.

Boland, K., Laight, P., Matson, R., Leslie, A., and Metz, P., 2007a, Rails to Resources to Ports. The Alaska Canadian Rail Link Project Phase 1 Feasibility Study: ALCAN RaiLink Inc., 12 p.

Boland, K., Laight, P., Matson, R., Leslie, A., and Metz, P., 2007b, Rails to Resources to Ports. The Alaska Canadian Rail Link Project Phase 1 Feasibility Study: ALCAN RaiLink Inc., 84 p.

Boland, K., Laight, P., Matson, R., Leslie, A., and Metz, P., 2007c, Rails to Resources to Ports. The Alaska Canadian Rail Link Project Phase 1 Feasibility Study: ALCAN RaiLink Inc., 67 p.

Boland, K., Laight, P., Matson, R., Leslie, A., and Metz, P., 2007d, Rails to Resources to Ports. Tourism Annex: ALCAN RaiLink Inc., 67 p.

Boland, K., Matson, R., Laight, P., Leslie, A., and Churchill, S., 2008, Yukon Short Track Report: ALCAN RaiLink Inc., 110 p.

Bond, B., 2004, Understanding Log Scales and Log Rules: University of Tennesee Agricultural Extension Service PB 1650, 8 p.

Brant, A.A., 1968, The pre-evaluation of the possible profitability of exploration prospects: Mineralium Deposita, v. 3, no. 1, p. 1-17.

Briggs, D.F., 2005, Bingham Canyon Mining Operations Report, 41 p.

Brogan, G.E., Cluff, L.S., Korringa, M.K., and Slemmons, D.B., 1975, Active faults of Alaska: Tectonophysics, v. 29, no. 1-4, p. 73-85.

Brooks, C., Powell, R., Shuchman, R., and Leonard, G., 2010, Developing and Applying a Geospatial Decision Support Tool for Efficient Identification of Wetlands Mitigation Sites: Washington, D.C., Transportation Research Board.

Bundtzen, T.K., 1982, Bedrock geology of the Fairbanks Mining District, western sector: Alaska Division of Geological & Geophysical Surveys, scale 1:24,000.

Burns, L.E., and Liss, S.A., 1999, Portfolio of Aeromagnetic and Resistivity Maps of Part of the Livengood Mining District: Alaska Division of Geological & Geophysical Surveys, 16 p.

Cady, J.W., 1991, Aeromagnetic map of Alaska from lat 65 degrees -68 degrees N, long 141 degrees -162 degrees W: U.S. Geological Survey Geophysical scale 1:500,000.

Carr, B., 2010, Phone Conference.

Cathrall, J.B., Antweiler, J.C., and Mosier, E.L., 1987, Ocurrance of Platinum in Gold Samples from the Tolovana and Rampart Mining Districts, Livengood Quadrangle, Alaska, 14 p.

Chadwick, J., 1995, Barrick Goldstrike: The Mining Magazine, no. November 1995, p. 251-263.

Cheng, G., 2005, A Roadbed Cooling Approach for the Construction of Qinghai-Tibet Railway: Cold Regions Science and Technology, v. 42, no. 2, p. 169-176.

Cheng, G., Sun, Z., and Niu, F., 2008, Application of the roadbed cooling approach in Qinghai-Tibet railway engineering: Cold Regions Science and Technology, v. 53, no. 3, p. 241-258.

Christensen, L.R., 2009, Supplemental Report to the U.S. Surface Transportation Board on Capacity and Infrastructure Investment: The Surface Transportation Board, Washington DC, 179 p.

Cobb, E.H., 1973, Placer Deposits of Alaska, United Geological Survey B1374, p. 220.

Columbia, B., 2010, Conversion Factors, Government of British Columbia v. 2010, no. 08-24-2010, http://www.empr.gov.bc.ca/Mining/Geoscience/MINFILE/ProductsDownloads/MINFILEDocumentation/CodingManual/Appendices/Pages/VII.aspx.

Combellick, R.A., 1984, Potential for earthquake induced liquefaction in the Fairbanks-Nenana area, Alaska: Fairbanks, Department of Natural Reources, Division of Geological and Geophysical Surveys, p. 13.

Costa Lima, G.A., and Suslick, S.B., 2006, Estimating the volatility of mining projects considering price and operating cost uncertainties: Resources Policy, v. 31, no. 2, p. 86-94.

Cox, D.P., and Singer, D.A., 1986, Mineral Deposit Models U. S. Geological Survey Bulletin 1693, p. 379.

Crimp, P., Phillips, S.J., and Worum, G.T., 1997, Timber Resources on State Forestry Lands in the Tanana Valley Department of Natural Resources, p. 27.

Davis, G.A., 1998, The minerals sector, sectoral analysis, and economic development: Resources Policy, v. 24, no. 4, p. 217-228.

De Geoffroy, J., and Wignall, T.K., 1970, Statistical decision in regional exploration; application of regression and Bayesian classification analysis in the southwest Wisconsin zinc area: Economic Geology, v. 65, no. 7, p. 769-777.

De Geoffroy, J., and Wignall, T.K., 1971, A probabilistic appraisal of mineral resources in a portion of the Grenville Province of the Canadian shield: Economic Geology, v. 66, no. 3, p. 466-479.

De Geoffroy, J., and Wignall, T.K., 1972, A Statistical Study of Geological Characteristics of Porphyry-Copper-Molybdenum Deposits in the Cordilleran Belt-Application to the Rating of Porphyry Prospects: Economic Geology, v. 67, no. 5, p. 656-668.

De Geoffroy, J., and Wu, S.M., 1970, A statistical study of ore occurrences in the greenstone belts of the Canadian Shield: Economic Geology, v. 65, no. 4, p. 496-504.

Delucchi, M.A., 1996, The Allocation of the Social Costs of Motor-Vehicle Use to Six Classes of Motor Vehicles: Institute of Transportation Studies University of California 10, 88 p.

Delucchi, M.A., 1998, The Annualized Social Cost of Motor-Vehicle Use in the United States, based on 1990-1991 Data: Summary of Theory, Data, Methods, and Results: Institute of Transportation Studies University of California 1, 62 p.

Drew, L.J., Bliss, J.D., Bowen, R.W., Bridges, N.J., Cox, D.P., DeYoung, J.H., Houghton, J.C., Ludington, S.D., Menzie, W.D., Page, N.J., Root, D.H., and Singer, D.A., 1986, Quantitative estimation of undiscovered mineral resources; a case study of U. S. Forest Service wilderness tracts in the Pacific mountain system: Economic Geology, v. 81, no. 1, p. 80-88.

Duvall, T.D., and Gribbin, D.J., 2011, Value of Life Guidence: Washington, D.C., U.S. Department of Transportation, p. 10.

Espinosa, A.F., 1984, Seismicity of Alaska and the Aleution Islands, 1960-1983: U.S. Geological Survey, scale 1:12,500,000.

Forbes, R.B., 1982, Bedrock geology and petrology of the Fairbanks Mining District: Alaska Division of Geological & Geophysical Surveys Alaska Open-File Report 169, 76 p.

Fox, O., 2006, Interior Alaska Seismicity, Alaska Earthquake Information Center, no. 20 May, http://www.aeic.alaska.edu/maps/interior_seismicity_map.html.

FRA, 2008, Energy, 2 p.

Freeman, C.J., 2010, Geologic Report SC-10EXE1, Geology and Mineralization of the Shorty Creek Project: Select Resources Corporation, 88 p.

Freeman, C.J., and Schaefer, J., 1996, Alaska Resource Data File: Fairbanks Quadrangle, U.S. Geological Survey, p. 355.

Frost, G.M., and Stanley, R.G., 1991, Compiled Geologic and Bouguer Gravity Map of the Nenana Basin Area, Central Alaska, U.S.G.S., p. 39 U. S. DEPARTMENT OF THE INTERIOR.

Fuglestad, T.C., 1983, Guidebook to Premafrost Engineering Problems Along the Alaska Railroad Between Anchorage and Fairbanks, DGGS, no. Guidebook 6, p. 88 Division of Geological and Geophysical Surveys.

Goering, D.J., 2003, Passively Cooled Railway Embankments for Use in Permafrost Areas: Journal of Cold Regions Engineering, v. 17, no. 3, p. 119-133.

Golder, and Associates, 2004, Five-Year Environmental Audit Fort Knox Mine, True North Mine and Twin Creek Road, 169 p.

Goldstrike, B., 2005, Barrick Gold Corporation Goldstrike Tour - August 2005, 33 p. [ppt].

Gordon, P., and Kolesar, P.E., 2010, A Note on Rail Transit Cost-Benefit Analysis: Do Non-User Benefits Make a Difference?, University of Southern California, p. 17.

Goter, S.K., 1989, Seismicity of Alaska, 1786-1987: U.S. Geological Survey, scale 1:2,500,000.

Grunsky, E.C., 1995, Grade and Tonnage Data for British Columbia Mineral Deposit Models, p. 13 B.C. Ministry of Energy, Mines and Petroleum Resources.

Haeussler, P.J., Schwartz, D.P., Dawson, T.E., Stenner, H.D., Lienkaemper, J.J., Sherrod, B., Cinti, F.R., Montone, P., Craw, P.A., Crone, A.J., and Personius, S.F., 2004, Surface Rupture and Slip Distribution of the Denali and Totschunda Faults in the 3 November 2002 M 7.9 Earthquake, Alaska: Bulletin of the Seismological Society of America, v. 94, no. 6B, p. S23-52.

Hall, M.H., 1985, Structural geology of the Fairbanks Mining District, central Alaska: Division of Geological & Geophysical Surveys PDF 85-61, 68, 62 sheets p.

Hansen, V.L., and Dusel-Bacon, C., 1998, Structural and kinematic evolution of the Yukon-Tanana upland tectonites, east-central Alaska: A record of late Paleozoic to Mesozoic crustal assembly: Geological Society of America Bulletin, v. 110, no. 2, p. 211-230.

Hanson, D., 2010, Draft Copy Timber Resources on State Forest Lands in the Tanana Valley Inventory Update 2010: Division of forestry, 140 p.

Hanson, M.E., 1992, Automobile Subsidies and Land Use: Estimates and Policy Responses: Journal of the American Planning Association, v. 58, no. 1, p. 60 - 71.

Hartwick, J.M., 1977, Intergenerational Equity and the Investing of Rents from Exhaustible Resources: The American Economic Review, v. 67, no. 5, p. 972-974.

Hartwick, J.M., 1978, Substitution Among Exhaustible Resources and Intergenerational Equity: The Review of Economic Studies, v. 45, no. 2, p. 347-354.

Henderson, R., Quandt, D., Ekstrom, C., and Triebel, K., 2008, Technical Report for the Fort Knox Gold Mine: Kinross, 79 p.

Hickman, R.G., Craddock, C., and Sherwood, K.W., 1977, Structural geology of the Nenana River segment of the Denali fault system, central Alaska Range: Geological Society of America Bulletin, v. 88, no. 9, p. 1217-1230.

Hickman, R.G., Craddock, C., and Sherwood, K.W., 1978, The Denali fault system and the tectonic development of Southern Alaska: Tectonophysics, v. 47, no. 3-4, p. 247-273.

Horkel, A., 1986, On the economic evaluation of individual regional mineral exploration projects: Mitt. osterr. geol. Ges., v. 78, p. 10.

Hughes, A., Tolley, J., and Ott, M., 2002, Vision: 2020, Statewide Transportation Policy Plan: Alaska DOT & PF, 199 p.

ICF, 2009, Federal Railroad Administration Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors, 156 p. [Final Report].

Instanes, A., Fannin, R.J., and Haldorsen, K., 1998, Mechanical and thermal stabilisation of fill materials for road embankment construction on discontinuous permafrost in Northwest Russia, Permafrost; Seventh International Conference Yellowknife, Canada, v. June 23-27, 1998, p. 495-500.

Jahnke, J.J., 2003, 2003 Annual Report, Alaska Division of Forestry, p. 56 Alaska Department of Natural Resources Division of Forestry.

Joint Departments of the Army and Air Force USA, 2004, Calculation Methods for Determination of Depths of Freeze and Thaw in Soils, *in* Defense, D.o.: Washington DC, Department of Defense, v. 6, no. Techinal Manual TM 5-852-6/AFR 88-19, p. 65.

Journal, M., 2011, An introduction to mining, or a place to refresh your understanding of the basic industry rules of thumb., Mining Explained, no. 1.

Karl, S.M., Ager, T.A., Hanneman, K., and Teller, S.D., 1988, Tertiary gold-bearing gravel at Livengood Alaska, U.S. Geological Survey Circular 1016, p. 61-63.

Kennecott, 2010, Mine facts, Rio Tinto, v. 2010, no. August 17, 2010, http://www.kennecott.com/educators/mine-facts/.

Kerr, T.F., 2006, Walter Creek Valley Fill Heap Leach Facility Project Description: Fairbanks Gold Mining, Inc., 74 p.

Kinross, 2007, 2007 Corporate Responsibility Report: Kinross, 11 p.

Kinross, 2008a, Fort Knox Annual Meeting March 12, 2008: Kinross, 41 p.

Kinross, 2008b, Kinross Reports Record 2008 Production and Revenue, 26 p. [News Release].

Kinross, 2009, Fairbanks Gold Mining, Inc., Fort Knox Mine 2008 Annual Activity Report, 28 p.

Klipfel, P., 2006, Summary Report on the Livengood Project, Tolovana District, Alaska, 37 p. [Summary Report].

Klipfel, P., Carew, T.J., and Jr., W.P., 2009, October 2009 Summary Report on the Livengood Project, Tolovana District, Alaska, 144 p. [Summary Report].

Knoles, J., 2011, Surfaced Lumber and Tongue and Groove: Fairbanks, Northland Wood, no. 7 June 2011, http://www.northlandwood.com/s4s.htm.

Knox, F., 2006, Fort Knox Reclaimation Plan June 2006, Kinross, p. 63.

Koulomzine, T., and Dagenais, R.W., 1959, Statistical determination of the chances of success in mineral exploration in Canada: Canadian Mining Journal, p. 107-110.

Kreig, R.A., and Reger, R.D., 1982, Air-photo Analysis and Summary of the Landform Soil Properties Along the Route of the Trans-Alaska Pipeline System, *in* Surveys, A.D.o.G.a.G.: College, Alaska Division of Geological and Geophysical Surveys, p. 155 Department of Natural Resources.

Leinart, J.B., 2009, Mine and Mill Equipment Costs an Estimator's Guide: Spokane Valley, WA, Jennifer B. Leinart.

Levinson, D., and Gillen, D., 1998, The Full Cost of Intercity Highway Transportation: Transportation Research, v. 3, no. 4, p. 17.

Litman, T., 2006, Comprehensive Evaluatin of Rail Transit Benefits: Victoria Transport Policy Institute, 6 p.

LRN, 2003, Fatality Rates: Transit Passengers vs. Motor Vehicle Occupants: Austin, Texas, Light Rail Now, no. 2/15/2011, http://www.lightrailnow.org/facts/fa_00020.htm.

Maillelle, B.D., 2010, Dalton-Elliott Highway Costs: Fairbanks, Administrative Officer, NR Maintenance & Operations, DOT&PF, Phone 907-451-5286.

McGroarty, S., 2006, Fort Knox Mine Project Draft Plan of Operations Admendment Approval, *in* Department of Natural Resources Division of Mining: Fairbanks, Fairbanks Gold MIning, Inc., p. 11.

McHattie, R., and Esch, D., 1988, Embankment Failure from Creep of Permafrost Soils, Case History Alaska Department of Transportation, USA, Book of Permafrost, Proceedings, 5th International Permafrost Conference: Trondheim, Norway, Tapis Publishers, p. 1292-1297.

McMahon, L.M., 2011, Inflation Data, Capital Professional Services, LLC, v. 2011, no. 03 March, http://inflationdata.com/inflation/inflation_rate/currentinflation.asp.

Metz, P.A., 1982, Bedrock geology of the Fairbanks Mining District, northeast sector: Alaska Division of Geological & Geophysical Surveys, scale 1:24,000.

Metz, P.A., 1987, Geological Factors Governing the Formation of the Gold Placer Depsits of the Fairbanks Mining District, Alaska, *in* Albanese, M., and Campbell, B., Proceedings of the Ninth Annual Alaska Conference on Placer Mining: University of Alaska Fairbanks Mineral Industrial Research Laboratory, p. 195-223.

Metz, P.A., 1994, Report for the Hearing For Final Approval - Weiss vs State of Alaska: Mineral, coal, and aggregate appraisal of Alaska Mental Health Trust Lands:, Metz and Associates: Fairbanks, Alaska, p. 67, Appendices A-H.

Metz, P.A., 2000, Mineral resources along the proposed extension of the Alaska Railroad from Fairbanks to the Canadian Border:, Conference on the Alaska-Canada Rail Link: Vancouver, B.C., January 20, 2000.

Metz, P.A., 2010, Personal Communication: Mining and Geological Engineering Dept., University of Alaska, Fairbanks, 306 Tanana Dr. Duckering 313, PO Box 755800, Fairbanks, AK 99775.

Metz, P.A., and Dixon, C., 1988, Mineral, coal and aggregate resource appraisal of Alaska Mental Health Trust Lands:, Metz, DeLong, and Associates: Fairbanks, Alaska, p. 153, Appendix.

Meyers, R., 2009, The Money Knob Gold Deposit: International Tower Hill Mines LTD, 35 p.

Mihalynuk, M.G., Nelson, J., Murphy, D.C., Brew, D.A., Erdmer, P., Hansen, V.L., and Oliver, D.H., 1999, Structural and kinematic evolution of the Yukon-Tanana upland tectonites, east-central Alaska: A record of late Paleozoic to Mesozoic crustal assembly: Discussion and Reply: Geological Society of America Bulletin, v. 111, no. 9, p. 1416-1422.

Miller, P., 2005, Tolovana Limestone Mine, Mining and Geological Engineering Dept., University of Alaska, Fairbanks, 306 Tanana Dr. Duckering 313, PO Box 755800, Fairbanks, AK 99775, p. 57.

Missanabie Cree First Nation, 2010, Mining Information Kit for Aboriginal Communities: Natural Resources Canada, http://www.nrcan.gc.ca/mms-smm/abor-auto/htm/kit-toc/kit-exp-eng.htm.

Molega, 2010, Molega Tours Vehicle Charters, no. 02 August 2010, http://www.molegatours.ca/vehicle-charters.php.

Murphy, J., and Delucchi, M., 1998, A Review of the Literature on the Social Cost of Motor Vehicle Use in the United States: Institute of Transportation Studies University of California, 28 p.

NHTSA, 2009, Early Estimate of Motor Vehicle Traffic Fatalities in 2008: Washington, NHTSA's National Center for Statistics and Analysis, p. 2.

NHTSA, 2010a, Early Estimate of Motor Vehicle Traffic Fatalities in 2009: Washington, NHTSA's National Center for Statistics and Analysis, p. 2.

NHTSA, 2010b, Fatality Analysis Reporting System Encylopedia, http://www-fars.nhtsa.dot.gov/States/StatesFatalitiesFatalityRates.aspx.

Noel, P., 2003, 2001 Alaska traffic accidents: Juneau, State of Alaska DOT&PF, p. 168.

O'Leary, B., 2010, Alaska Railroad Corporation 2009 Annual Report: Alaska Railroad Corporation, 44 p.

Oliver, D.H., and Dusel-Bacon, C., 2001, Kinematic Analysis from Tectonites in the Northern Part of the Big Delta Quadrangle, East-Central Alaska: U.S. Geological Survey Professional Paper 1678.

Page, R.A., Plafker, G., and Pulpan, H., 1995, Block rotation in east-central Alaska: A framework for evaluating earthquake potential?: Geology, v. 23, no. 7, p. 629-632.

Palin, S., 2008, Alaska Economic Performance Report 2007, *in* Department of Commerce, C., and Economic Development, State of Alaska, p. 58.

Parnell, S., 2009, Alaska Economic Performance Report 2008, *in* Department of Commerce, C., and Economic Development, State of Alaska, p. 56.

Parsons, 2000, Tanana State Forestry Lands, Periodic Sustained Yield Analysis: Parsons and Associates, 20 p.

Penwarden, S., 2006, In Support of Fort Knox, p. 9.

Pewe, T.L., 1948, Preliminary Report of Permafrost Investigations in the Dunbar Area, Alaska, no. c-0042, p. 3.

Pewe, T.L., 1975, Quaternary Stratigraphic Nomenclature in Unglaciated Central Alaska, U. S. Geological Survey Professional Paper 862, p. 24.

Pewe, T.L., 1982, Geologic hazards of the Fairbanks area, Special Report 15, Department of Natural Resources, Division of Geological & Geophysical Surveys, p. 119.

Plafker, G., and Berg, H.C., 1994, The Geology of Alaska, The Geological Society of America, v. G-1, 1055 p.

Pontius, J.A., 2009, International Tower Hill Mines Ltd. Positive Preliminary Economic Assessment Results Heap Leach Phase, Livengood Gold Project, Alaska Life of project annual gold production - 459,000 ounces/year for 12.6 years, 8 p. [Press Release].

Pontius, J.A., 2010a, Developing North America's Next Generation of Gold Mines, 5 p. [Press Release].

Pontius, J.A., 2010b, International Tower Hill Announces Resource Update, Livengood Gold Project, Alaska, 6 p. [Press Release].

Pontius, J.A., 2010c, International Tower Hill Begins 50,000 Metre 2010 Exploration Drill Program at Livengood Project, Alaska Expands Livengood Land Package by 60% to 70Km^2, 5 p. [Press Release].

Pontius, J.A., 2010d, International Tower Hill Continues Expansion of the Core Zone at Depth at the Livengood Project, Alaska: International Tower Hill Mines [Press Release].

Pontius, J.A., 2010e, International Tower Hill Intersects High-Grade Gold Zone and Expands New Olive Zone at Livengood Gold Deposit, Alaska: International Tower Hill Mines, 8 p. [Press Release].

Pontius, J.A., 2010f, International Tower Hill Mines Ltd. Reports Positive Preliminary Economic Assessment Results – Combined Milling and Heap Leach Processing, Livengood Gold Project, Alaska, 9 p. [Press Release].

Pontius, J.A., 2010g, International Tower Hill Reports Final Holes from Winter Program and Start of Summer Drill Program at its Livengood Project, Alaska, 5 p. [Press Release].

Pontius, J.A., 2010h, International Tower Hill Reports Latest Results from 22 Drill Holes at the Expanding Livengood Gold Deposit, Alaska: International Tower Hill Mines, 8 p. [Press Release].

Pontius, J.A., 2010i, Project Enhancement Options for its Preliminary Economic Assessment Study for the Livengood Gold Project, Alaska: International Tower Hill Mines, 9 p. [Press Release].

Price, J.G., Meeuwig, R., Muntean, J., Castor, S., Hess, R., and Davis, D.A., 2006, The Nevada Mineral Industry 2005: University of Nevada Reno, 88 p.

Prindle, L.M., 1913, A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U.S. Geological Survey Bulletin 525, scale 1:250,000.

Pulpan, H., 1988, Seismic-hazard analysis of the Nenana agricultural development area, Central Alaska: Fairbanks, Department of Natural Resources, Division of Geologicl and Geophysical Surveys, p. 32.

Qihao, Y., Fujun, N., Xicai, P., Yang, B., and Mingyi, Z., 2008, Investigation of embankment with temperature-controlled ventilation along the Qinghai-Tibet Railway: Cold Regions Science and Technology, v. 53, no. 2, p. 193-199.

Qin, Y., Zhang, J., Zheng, B., and Ma, X., 2009, Experimental study for the compressible behavior of warm and ice-rich frozen soil under the embankment of Qinghai-Tibet Railroad: Cold Regions Science and Technology, v. 57, no. 2-3, p. 148-153.

Qingbai, W., Shiyun, Z., Wei, M., and Luxin, Z., 2007, Qinghai-Xizang Railroad Construction in Permafrost Regions: Journal of Cold Regions Engineering, v. 21, no. 2, p. 60-67.

Quan, X., Li, N., and Li, G., 2006, A new ripraped-rock slope for high temperature permafrost regions: Cold Regions Science and Technology, v. 45, no. 1, p. 42-50.

Railcar, 2010, A new modern Passenger Train, *in* US Railcar, L., no. 27 May 2010, http://www.usrailcar.com/dmu-specs.php.

Raju, S., 2008, Project NPV, Positive Externalities, Social Cost-Benefit Analysis - The Kansas City Light Rail Project: Journal of Public Transportation, v. 11, no. 4, p. 59-88.

Reger, R.D., Stevens, D.S.P., and Smith, R.L., 2003, Survey of geology, geologic materials, and geologic hazards in proposed access corridors in the Fairbanks Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys, scale 1:250,000.

Ridgway, K.D., Trop, J.M., Nokleberg, W.J., Davidson, C.M., and Eastham, K.R., 2002, Mesozoic and Cenozoic tectonics of the eastern and central Alaska Range: Progressive basin development and deformation in a suture zone: Geological Society of America Bulletin, v. 114, no. 12, p. 1480-1504.

Robinson, M.S., 1982, Bedrock geology of the Fairbanks Mining District, southeast sector: Alaska Division of Geological & Geophysical Surveys, scale 1 sheet, scale 1:24,000.

Rogers, B., and Calvin, J., 1999, Economic Impact of the Fort Knox Mine: Information Insights and McDowell Group, 16 p.

Rutson, V., 2009, Final Environmental Impact Statement, STB Finance Docket No. 34658, Alaska Railroad Corporation and Operation of a Rail Line between North Pole and Delta Junction, Alaska: Surface Transportation Board.

Sampson, G.R., Hees, W.W.S.v., Setzer, T.S., and Smith, R.C., 1988, Potential for Forest Products in Interior Alaska, Forest Service, Pacific Northwest Research Station PNW-RB-153, p. 28.

Shur, Y., and Kanevskiy, M., 2010, Geotechnical Investigations for the Dalton Highway Innovation Project as a Case Study of the Ice-rich Syngenetic Permafrost: Institute of Northern Engineering, 77 p.

Singer, D., 1996, Grade and Tonnage Models for the Analysis of Nevada's Mineral Resources, Chapter 11, 11-18 p.

Singer, D.A., 2007, Introduction to Quantitative Mineral Resource Assessments and Required Deposit Models, 122 p.

Singer, D.A., 2008, Mineral deposit densities for estimating mineral resources: Mathematical Geosciences, v. 40, no. 1, p. 33-46.

Singer, D.A., Berger, V.I., and Moring, B.C., 2002, Porphyry Copper Deposits of the World: Database, Maps, and Preliminary Analysis, U.S. Geological Survey Open-File Report 02-268, p. 62.

Singer, D.A., Menzie, W.D., and Long, K.R., 1998, A simplified economic filter for open-pit gold-silver mining in the United States, 13 p.

Southworth, D.D., 1982, Cobalt Investigations in the Livengood Area, Bureau of Mines, p. 24 United States Department of the Interior.

Stickel, J., 2010a, 2006 Alaska Traffic Crashes: Crash Data: State of Alaska DOT&PF, 50 p.

Stickel, J., 2010b, 2006 Alaska Traffic Crashes: Person Data: State of Alaska DOT&PF, 175 p.

Stickel, J., 2010c, 2006 Alaska Traffic Crashes: Vehicle Data: State of Alaska DOT&PF, 114 p.

Stickel, J., 2010d, 2007 Alaska Traffic Crashes: Crash Data: State of Alaska DOT&PF, 105 p.

Thomas, S.E., 1995, Moose-vehicle accidents on Alaska's rural highways: Fairbanks, State of Alaska DOT & PF, p. 66.

Till, A.B., Roeske, S.M., Bradley, D.C., Friedman, R., and Layer, P.W., 2007, Early Tertiary transtension-related deformation and magmatism along the Tintina fault system, Alaska: Geological Society of America Special Papers, v. 434, p. 233-264.

Toman, M.A., 1994, Economics and "Sustainability": Balancing Trade-Offs and Imperatives: Land Economics, v. 70, no. 4, p. 399-413.

U.S. Geological Survey, 2010, Mineral Commodity Summaries 2010, U.S. Geological Survey, p. 193.

Ulmer, F., 2005, Alaska Railroad Pulls Jobs and Income Into State Economy: University of Alaska R.S. No. 63, 4 p.

Wahrhaftig, C., 1965, Physiographic Divisions of Alaska, U. S. Geological Survey Professional Paper, p. 51.

Wahrhaftig, C., Turner, D.L., Weber, F.R., and Smith, T.E., 1975, Nature and timing of movement on Hines Creek strand of Denali fault system, Alaska: Geology, v. 3, no. 8, p. 463-466.

Weber, F.R., 1971, Preliminary engineering geologic maps of the proposed trans-Alaska pipeline route, Fairbanks and Big Delta quadrangles: U.S. Geological Survey 71-317, 1 p.

Wesson, R.L., Frankel, A.D., Mueller, C.S., and Harmsen, S.C., 1998, Seismic-hazard maps for Alaska and the Aleutian Islands: U.S. Geological Survey.

Wesson, R.L., Frankel, A.D., Mueller, C.S., and Harmsen, S.C., 1999, Probabilistic Seismic Hazard Maps of Alaska, 43 p.

White, B.A., Gunther, T.M., Johnson, R., and Adams, R.L., 1989, Potential supply of minerals from the White Mountains National Recreation Area and Part of the North Steese National Conservation Area Alaska: Bureau of Mines OFR-12-89 376 p.

Whitney, J.W., 1975, A resource analysis based on porphyry copper deposits and the cumulative copper metal curve using Monte Carlo simulation: Economic Geology, v. 70, no. 3, p. 527-537.

Wilson, F.H., Dover, J.H., Bradley, D.C., Weber, F.R., Bundtzen, T.K., and Haeussler, P.J., 1998, Geologic Map of Central (Interior) Alaska: U.S. Geological Survey OFR 98-133, scale 1:250,000.

Wilson, T., and Harris, D., 1992, Estimation of exploration potential of a metallogenic unit by parametric modeling of the distribution of mineral occurrences when exploration is incomplete. Case study: Walker Lake quadrangle of Nevada and California: Mathematical Geology, v. 24, no. 7, p. 789-805.

Wilson, T.B., and Amavilah, V.H., 2007, The Economic Value of Industrial Minerals and Rocks for Developing Countries: A Discussion of Key Issues: Munich Personal RePEc Archive 2214, 20 p.

WRCC, 2010, Alaska Climate Summaries, no. 10 December 2010, http://www.wrcc.dri.edu/summary/climsmak.html.

Wright, G., and Czelusta, J., 2002, Resource-Based and Economic Growth, Past and Present: Stanford University, 46 p.

Wright, G., and Czelusta, J., 2003, Mineral Resources and Economic Development: Stanford University, 39 p.

Wu, J., Ma, W., Sun, Z., and Wen, Z., 2010, In-situ study on cooling effect of the two-phase closed thermosyphon and insulation combinational embankment of the Qinghai-Tibet Railway: Cold Regions Science and Technology, v. 60, no. 3, p. 234-244.

Xuefu, Z., Jianzhang, X., Yaonan, Z., and Shengxie, X., 2007, Study of the function of the insulation layer for treating water leakage in permafrost tunnels: Applied Thermal Engineering, v. 27, no. 2-3, p. 637-645.

Ybarra, S.j., 2001, The Potential for Shifting Virginia's Highway Traffic to Railroads, 50 p. [Report of the Secretary of Transportation].

Young, R., 2010, Department of Transportation Cheif of Commerical Vehical Inforcement, Huffman Business Park, 11900 Industry Way, Building M, Anchorage, AK 99515.

Yu, W.B., Lai, Y.M., Sun, Z.Z., Jin, H.J., and Zhang, X.F., 2006, Experimental studies on the ripped-rock revetment embankment in permafrost regions of the Qinghai-Tibet railroad: Cold Regions Science and Technology, v. 45, no. 1, p. 1-7.

Zhang, D., and Bliss, J., 1998, Alabama Stumpage Price Trends: Alabama Cooperative Extension System ANR-1086, 4 p.

Appendix

ITH, Livengood Project Press Releases

December 8, 2010	International Tower Hill Mines Advances Livengood Gold Project Towards Potential Production Decision with Prefeasibility Study and Augmented Development Team
November 29, 2010	International Tower Hill Mines Intersects 112 metres of 2.63 g/t gold at the Livengood Gold Project, Alaska
November 16, 2010	International Tower Hill Defines Significantly Higher Grade Near Surface Zones at Livengood Project, Alaska
November 10, 2010	International Tower Hill Mines Ltd. Announces Closing of CAD 105,375,000 in Equity Financings
October 19, 2010	International Tower Hill Mines Ltd. Announces Launch of New Website
October 7, 2010	International Tower Hill Continues Expansion of the Core Zone at Depth at the Livengood Project, Alaska
September 13, 2010	Project Enhancement Options for its Preliminary Economic Assessment Study for the Livengood Gold Project, Alaska
September 9, 2010	International Tower Hill Intersects High-Grade Gold Zone and Expands New Olive Zone at Livengood Gold Deposit, Alaska
August 17, 2010	International Tower Hill Reports Latest Results from 22 Drill Holes at the Expanding Livengood Gold Deposit, Alaska
August 12, 2010	International Tower Hill Receives Share Ownership Top-up Notice from AngloGold Ashanti for 415,041 Shares
August 3, 2010	International Tower Hill Mines Ltd. Reports Positive Preliminary Economic Assessment Results -- Combined Milling and Heap Leach Processing, Livengood Gold Project, Alaska
July 27, 2010	International Tower Hill Reports Initial Drill Results from the Summer 2010 Livengood Drill Program, Alaska
July 20, 2010	International Tower Hill Announces Results for First 16 Holes of Summer 2009 Drill Program at Livengood Gold Deposit, Alaska

June 16, 2010	International Tower Hill Announces Resource Update, Livengood Gold Project, Alaska
June 1, 2010	International Tower Hill Reports Final Holes from Winter Program and Start of Summer Drill Program at its Livengood Project, Alaska
May 28, 2010	International Tower Hill Reports New Flotation and Column Leach Results for the Livengood Project, Alaska
May 21, 2010	Karl Hanneman Joins International Tower Hill as Livengood Project Manager
May 14, 2010	International Tower Hill Plans to Undertake Spin-out Transaction to Create Two Independent Companies
May 11, 2010	International Tower Hill Continues to Grow New High-Grade SW Zone, Livengood Project, Alaska
April 26, 2010	International Tower Hill Expands Higher Grade SW and Sunshine Zones at Livengood Project, Alaska
April 13, 2010	International Tower Hill Mines Announces the Appointment of Timothy Haddon and Daniel Carriere as new Directors
April 8, 2010	International Tower Hill Continues to Expand Livengood Deposit in the Sunshine-Core Zone Gap Area
March 22, 2010	International Tower Hill Expands Livengood Deposit with First Results of Winter Drilling Program
March 10, 2010	International Tower Hill Increases Indicated Resources at Livengood Gold Project, Alaska Indicated Resource 9.3M ounces of gold @ 0.5g/t Gold cutoff
March 4, 2010	International Tower Hill Signs LOI to Form Production Joint Venture on Terra Project, Alaska
March 2, 2010	International Tower Hill Announces First Two Holes of 2009 Winter Drill Program, Livengood Project, Alaska: 206 metres of 1.40 g/t Gold (including 38.1 meter of 3.08 g/t gold) and 38 metres of 1.23 g/t Gold
February 11, 2010	International Tower Hill Receives Share Ownership Top-up Notice from AngloGold Ashanti
February 4, 2010	International Tower Hill Begins 50,000 Metre 2010 Exploration Drill Program at Livengood Gold Project, Alaska Expands Livengood Land

	Package by 60% to 70 Km^2
January 19, 2010	International Tower Hill Announces New Positive Metallurgical Results from Sunshine Zone, Livengood Gold Project, Alaska
January 12, 2010	International Tower Hill Mines Ltd. Hires Chief Operating Officer for the Development of its Livengood Project, Alaska
December 7, 2009	International Tower Hill Continues to Expand Mineralization at Sunshine & Money Knob Zones, Livengood Gold Project, Alaska
November 12, 2009	International Tower Hill Continues to Expand Livengood Gold Project, Alaska
November 8, 2009	Positive Preliminary Economic Assessment Results Heap Leach Phase, Livengood Gold Project, Alaska
November 2, 2009	International Tower Hill Continues to Expand the Livengood Gold Project, Alaska
October 13, 2009	International Tower Hill Expands Livengood Gold Resource by 64%
September 30, 2009	International Tower Hill Expands the Sunshine Zone at Livengood Gold Project, Alaska
September 9, 2009	International Tower Hill Announces Latest Drill Results From Livengood Gold Project, Alaska
August 27, 2009	International Tower Hill Announces Latest 34 Drill Holes from Livengood Gold Project, Alaska
August 5, 2009	International Tower Hill Delineates Major New Zone of Gold Mineralization at Livengood Gold Project, Alaska
July 10, 2009	International Tower Hill Receives Share Ownership Top-up Notice from AngloGold Ashanti
June 30, 2009	International Tower Hill Mines Retains Renmark Financial Communications Inc.
June 25, 2009	International Tower Hill Announces Resource Update at Livengood, Alaska
June 10, 2009	International Tower Hill Mines Livengood Gold Project, Alaska Summer Drilling Program Commences
May 12, 2009	International Tower Hill Announces Latest Winter Program Drill Results From NE and SW Zones, Livengood Gold Deposit, Alaska

April 23, 2009	International Tower Hill Reports Extension of High Grade SW Zone and Expansion of Livengood Gold Deposit, Alaska
April 15, 2009	International Tower Hill's Livengood Project Returns 89% Gold Recovery from Recent Metallurgical Testwork
April 2, 2009	International Tower Hill Expands Livengood Southwest Zone Discovery
March 12, 2009	Steve Aaker Joins the Board of Directors of International Tower Hill Mines Ltd.
March 10, 2009	International Tower Hill Mines Ltd. Doubles Planned 2009 Drill Program for Livengood Gold Project, Alaska
March 4, 2009	International Tower Hill Mines Ltd. Closes $10,500,000 Bought Deal Equity Financing
February 17, 2009	International Tower Hill Mines Ltd. Announces Increase in Bought Deal Equity Financing
February 11, 2009	International Tower Hill Mines Ltd. Announces Bought Deal Equity Financing
February 9, 2009	International Tower Hill Mines Livengood Gold Project, Alaska - Winter Drilling Program Commences
January 28, 2009	International Tower Hill Mines Livengood Gold Project, Alaska Estimated Gold Resource Increases by 70% 3.41M Ounces Gold Indicated and 3.39M Ounces Gold Inferred
January 13, 2009	International Tower Hill Continues to Expand Livengood Gold Deposit
December 10, 2008	Livengood Gold Deposit Expands in all Directions
November 17, 2008	ITH's Multi-Million Ounce Livengood Gold Deposit Expanded by Step out Drilling
October 29, 2008	ITH Doubles Gold Resource at Livengood Project, Alaska
September 30, 2008	Multiple Gold Intersections Expand ITH's Livengood Deposit
September 4, 2008	Livengood Deposit Significantly Expands High Grade Core Zones
July 23, 2008	ITH intersects additional bulk-tonnage-grade gold intercepts at Livengood Deposit, Alaska
July 16, 2008	International Tower Hill Amends Options

June 26, 2008	ITH Drills 202.69 Metres of 1.37 g/t Gold at Livengood Deposit, Alaska
May 12, 2008	ITH Commences 42,000 metre Resource Drilling Program at the Livengood Gold Project, Alaska
February 18, 2008	ITH Reports Multi-Million Ounce Inferred Gold Resource at Livengood Project, Alaska
January 29, 2008	ITH Outlines Planned US$11M Exploration Program for 2008
November 16, 2007	ITH's Livengood Gold Deposit Continues to Grow Step-out drilling dramatically expands bulk tonnage potential
September 27, 2007	ITH Continues to Significantly Expand Sediment Hosted Mineralization at Livengood Gold Deposit, Alaska
August 1, 2007	ITH Discovers New Sediment Hosted High-Grade Gold Mineralization at Livengood Project, Alaska Intercepts Include 8.8m of 9.95 g/t Gold and 8.5m of 9.64 g/t Gold
June 19, 2007	ITH Signs Option Agreement to Earn Interest in New High-Grade Alaskan Gold Project
June 14, 2007	ITH Expands New High Grade Gold Zones with Ongoing Drill Program at its Bulk Tonnage Livengood Project, Alaska
April 12, 2007	ITH Announces the Beginning of Drilling at Livengood and Outlines USD7M North American Exploration Program for 2007
January 23, 2007	ITH Intercepts New High Grade Gold Zone at Its Bulk Tonnage Livengood Project, Alaska
October 11, 2006	ITH Consolidates Livengood Gold Project, Alaska
September 27, 2006	2006 Annual Meeting Results
September 18, 2006	International Tower Hill Launches New Corporate Website

http://www.ithmines.com/s/Livengood.asp